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LONCHOCARPUS SPECIES (BARBASCO, CUBE, HAIARI, NEKOE, AND TIMBO) USED AS INSECTICIDES

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Introduction

Rotenone, one of the most potent insecticidal constituents of derris root, was isolated from cube in 1929 by Clark (87). This discovery immediately focused the attention of the insecticide industry upon this South American fish poisoning plant.

Although cube root had been shown by McIndoo and Sievers (239) in 1924 to have value against certain species of insects, the fact that its botanical origin was in doubt and that nothing was known of its chemical composition retarded its development as an insecticide. In 1930 the identification of one of the most potent kinds of Peruvian cube as Lonchocarpus nicou (Aubl.) DC. by Killip and Smith (209) enabled the systematic collection and cultivation of the plant to be undertaken on a commercial scale. During the past five years growing interest has been shown in cube by entomologists, chemists, insecticide manufacturers, and exporters of South American products, and recently it has been brought into the United States in commercially significant quantities.

It is the purpose of this compilation to bring together all the data relating to cube and to other plants of the genus Lonchocarpus that are known to have insecticidal action. It is hoped that this publication will be helpful to those interested in insect control and more especially that it will stimulate research to fill many gaps in our present knowledge.

Definitions

Lonchocarpus (family Fabaceae) is a genus of tropical shrubs and trees comprising about 60 species (132). The name means lance-fruit, from the shape of the pod (48). Certain species of Lonchocarpus were formerly assigned to Sphinctolobium by Vogel (391), to Neuroscapha by Tulasne (370, 371) and to Philenoptera by Fenzl (136) and Richard (285). According to Dalla Torre and Harms (108) the synonomy of Lonchocarpus is as follows:

Clompanus Aubl., Hist. pl. Gui. franc. II. (1775) 773.
Robinia Aubl., ibid. 768.
Sphinctolobium Vog. in: Linnaea XI. (1837) 417.
Clomopanus Steud., Nom. ed. 2. I. (1840) 386.
Neuroscapha Tul. in: Ann. sc. nat. 2. ser. XX. (1843) 137.
Philenoptera Fenzl in: Flora XXVII. (1844) 312.
Icthyoctonum Boiv. ex Baillon in: Bul. Soc. Linn. Paris I. (1884) 440.

The genus is represented in the West Indies, Mexico, Central America, tropical South America, tropical and southern Africa, Madagascar, and Australia. For the most part the 40 species found in middle America are not found elsewhere. Among these species there are many trees with hard, fine-grained wood. Greshoff (158, 160, 162) has listed 7 or 8 species of Lonchocarpus as fish poisons, and Roark (301) in 1933 listed 4 known species and 3 suspected species as having insecticidal value.

These fish-poisoning species are known under different names by the natives of the various South American countries. For example, "cube" is used in Peru, "timbo" in Brazil, "haiari" in British Guiana, "nekoe" in Dutch Guiana, and "barbasco" throughout the Spanish-American countries to designate those species of Lonchocarpus having toxicity to fish. These terms are not, however, co-extensive. For example, while all species of Lonchocarpus which have fish-poisoning properties are called cube in Peru, the term cube is also applied to fish-poisoning plants belonging to other genera of Fabaceae (e. g., Tephrosia) and even to other families (e. g., Serjania of the Sapindaceae). The term "barbasco" is also applied to any fish-poisoning plant in Spanish-speaking countries.

These terms may be more fully defined as follows:

Barbasco is the general word for fish-poison plants in Spanish-speaking countries. "The word barbasco is said to be derived from Verbascum, a genus of Scrophulariaceous plants used formerly in Spain and other European countries as fish poisons. From this we have also embarbascar, to fish with poisonous plants, and barbascal, a plantation upon which fish poisons are grown." (210).

Killip and Smith (211) list the following species of Lonchocarpus to which the term barbasco is applied:

Common name	Species of Lonchocarpus
Barbasco	L. guaricensis
Barbasco	L. nicou
Barbasco del monte	L. nicou
Barbasco legitimo	L. nicou

Cube is a Peruvian word which has two meanings: 1. Barbasco, any fish-poison plant. 2. Any species of Lonchocarpus, more especially L. nicou [Roark (305); based on information from Allen (38); Clum (97); Dennis (115, 117); Ives (188); Kahn & Co. (205); Killip (207); Killip and Smith (209, 210); McKee (240); Makinson (243, 244); Mulford (254): Safford (319); Seil, Putt and Rusby (331); Sims (334); Townsend (367, 368); Trueblood (369); and the United States Department of Commerce (385).]

Young (409), of the Division of Plant Exploration and Introduction of the Bureau of Plant Industry, United States Department of Agriculture, wrote to a correspondent as follows on November 23, 1934:

> "The name cube has been applied at times to a number of quite different plants that are sources of the so-called fish poisons and without knowing what one you may have in mind it would not be possible to write you intelligently on the subject."

In their list of American plants used as fish poisons, issued in February, 1935, Killip and Smith (211) state that cube is used in Peru to designate Lonchocarpus nicou and Tephrosia toxicaria.

Haiari is a word used in British Guiana to designate certain species of Lonchocarpus, including L. nicou. The variant hajari is used in Dutch Guiana. Haiari is L. densiflorus, according to Thurn (365). Schomburgk (327) refers to haiari as Lonchocarpus densiflorus Benth. Howes (182) states that according to Altson the Arawak Indians know the white haiari by the name of "Haiari" and the black they call "Wacorocordak." The white is known to the Warrau Indians as "E-Yari" and to the Patamona as "A-Ya." Archer (40) states that black haiari, white haiari, and red haiari collected under the general term of haiari are undetermined species of Lonchocarpus. Killip and Smith (211) state that haiari, heierri, black haiari, white haiari and real haiari are all L. nicou; that bastard haiari is L. densiflorus; that haiarballi is also L. densiflorus but that haiariballi is Muellera moniliformis.

Nekoe. Pool (275) in 1898 identified nekoe as the stems of Lonchocarpus violaceous Benth. Greshoff (161) in 1901 reported that nicou, a fish-poisoning liana of French Guiana, is known in Surinam as nekoe and is Lonchocarpus rufescens (= Robinia nicou Aubl.). Borst Pauwels (63) in 1903 stated that the Surinam fish poison nekoe is apparently Lonchocarpus nicou DC. Bredeman (65) in 1930 identified nekoeline from Dutch Guiana as the root of Lonchocarpus nicou DC. Killip and Smith (211) in 1935 identified nekoe as Lonchocarpus chrysophyllus. Nekoe is also known as tiengihoede (signifying stinkwood), tetei, touw, and hajari.

Timbo. Sloane (337) in 1725 wrote: "Timbo, a sort of With intoxicates Fishes" but did not identify it. Von Spix and von Martius (343) in 1828 stated that timbo, identified as Paullinia pinnata, is used in Brazil to stupefy fish. Martin in 1877 (250) reported the results of the first chemical examination of timbo, identified as Paullinia pinnata. Von Sobieranski (341) in 1890 spoke of timbo as Paullinia pinnata from northern Brazil. Another variety of timbo is the root bark of L. peckolti. Pfaff (269) in 1891 included Tephrosia toxicaria and Paullinia pinnata in a list of fish-poisoning plants known in Brazil under the designation "timbo". According to Greshoff (159) timbo comes from Derris negrensis Benth.; and according to Lyons (234) in Brazil Serjania lethalis A. St. Hil. is used as a fish poison under the name of timbo. The United States Dispensatory (406), 21st edition, defines timbo as follows: "This name is applied in Brazil to various sapindaceous plants used as fish poisons. Among these is Serjania curassavica Radlk. (= Paullinia pinnata L.)" Freise (140) in 1931 stated that the name timbo is used for a long series of plants of various families including two species of Tephrosia and five species of Paullinia (Sapindaceae). Lonchocarpus peckolti Wawra is called timbo-peixe or timbo-boticario in the states of Rio de Janeiro and Espirito Santo, Brazil. Quarton (279), American Consul at Guayaquil, Ecuador, reported under date of March 22, 1933, that in eastern Ecuador Lonchocarpus nicou is generally called timbo. Ives (188), of the Bureau of Foreign and Domestic Commerce, United States Department of Commerce, in 1934 compiled a list of insecticidal and other toxic plants found in Brazil, and in 1935 Killip and Smith (211) published a list of South American plants used as fish poisons. Many of these are called timbo. The following information is taken largely from Ives and from Killip and Smith:

Common Name	Botanical Name
Timbo	Derris guianensis
	" negrensis
	Enterolobium timbouva
	Indigofera lespedezioides
	Lonchocarpus denudatus
	" floribundus
	" nicou
	" rariflorus
	Magonia glabrata
	Paullinia australis
	" carpopodea
	" cururu
	" pinnata
	" trigonia
	Piscidia erythrina
	Serjania caracasana
	" ichthyoctona
	" lethalis
	Tephrosia toxicaria
	" nitens
Timbo aitica	Paullinia trigonia
" amarello	Serjania ovalifolia
" assu	Derris guianensis
	Lonchocarpus nicou
	Magonia glabrata
	Serjania laruotteana
Timbo boticaria	Lonchocarpus peckholti
" branco	Serjania glutinosa
" bravo	" erecta
" cabelludo	Paullinia rubiginosa
	Serjania cuspidata
" cipo	Paullinia pinnata
" citica	" trigonia
" cururu	Lonchocarpus rariflorus
" da matta	Derris guianensis
	" negrensis
Timbo das restingas	Serjania dentata
" de Cayenne	Tephrosia toxicaria
" de cono	Clitoria amazonum
" de leite	Serjania caracasana
" de peixe	Clitoria guianensis
	Serjania acuminata
	" cuspidata
	" ichthyoctona
	" serrata

Common Name	Botanical Name
Timbo de Rio Grande	*Paullinia australis*
" des restingas	*Serjania dentata*
" do campo	" *tristis*
	" *caracasana*
Timbo guassis	*Derris negrensis*
" legitimo	*Lonchocarpus nicou*
	Serjania acuminata
	" *caracasana*
	" *serrata*
Timbo macacinho	*Lonchocarpus nicou*
" macaquinho	" "
" miudo	*Serjania communis*
" peba	*Paullinia meliaefolia*
	Mahonia glabrata
" pirango	*Serjania caracasana*
" rana	*Derris guianensis*
	Lonchocarpus nicou
Timbo titica	*Serjania grandiflora*
" uba	*Enterolobium timbouva*
" urucu	*Lonchocarpus urucu*
" venenoso	" *floribundus*
" verdadeiro	*Serjania caracasana*
" vermelbo	" *purpurea*
" vermelho	*Paullinia meliaefolia*
Timbocaa	*Tephrosia nitens*
	" *sessiliflora*
	" toxicaria
Timboliane	*Paullinia pinnata*
Timbosinho	*Serjania caracasana*

Additional plants called timbo are listed by Ducke (126, 127).

According to Correa (104), cipo timbo is *Paullinia* spp. and cipo de timbo is *Serjania erecta*.

Common Names

Lonchocarpus species are known in various countries by the following common names:

Species	Common Name	Country	Reference
L. chrysophyllus Kleinh.	Nekoe	Dutch Guiana	Killip & Smith, 211
"	Neki	"	"
L. cyanescens	Gara	Sierra Leone	Rupe, 317
L. densiflorus Benth.	Bastard haiari	British Guiana	Killip & Smith, 211
"	Haiarballi?	"	"
"	Haiari	"	Thurn, 365
"	Haiari root	"	Anon., 1
"	Wacorocordak?	"	Killip & Smith, 211
"	Majomo	Venezuela	"
L. denudatus Benth.	Timbo	Brazil	"
L. floribundus Benth.	Timbo	"	"
"	Timbo venenoso	"	Ives, 188
"	Bois enivrant	French Guiana	Killip & Smith, 211
"	Inecou	"	"
L. guaricensis Pittier	Barbasco	Venezuela	"
L. latifolius (Willd.) H.B.K.	Acurutu	"	"
"	Savonette	West Indies	"
"	Savonette jaune	"	"
L. nicou	Timbo	Brazil	Ives, 188
"	Timbo assu	"	Killip & Smith, 211
"	Timbo legitimo	"	" 209
"	Timbo macinho	"	" 211
"	Timbo macquinho	"	"
"	Timbo rana	"	"

Species	Common Name	Country	Reference
L. nicou	White haiari?	British Guiana	Killip & Smith, 211
"	Yarro-conalli?	"	"
"	Hajari	Dutch Guiana	Borst Pauwels, 63
"	Nekoe	"	Greshoff, 161
"	Nekoeline	"	Bredeman, 65
"	Stinkwood (Stinkhout)	"	Borst Pauwels, 63
"	Tetei	"	"
"	Tiengihoede	"	"
"	Touw	"	"
"	Bois enivrant	French Guiana	Coudreau, 105; Killip & Smith, 211
"	Inekou	"	Killip & Smith, 211
"	Liane a enivrer les poissons	"	Aublet, 41
"	Nesi	"	Coudreau, 105; Killip & Smith, 211
"	Nicou	French Guiana	Killip & Smith, 211; Aublet, 41
"	Salisali	"	Coudreau, 105
"	Barbasco	Peru	Killip & Smith, 211
"	Barbasco del	"	"
"	monte		
"	Barbasco legitimo	"	"
"	Conape	"	"
"	Conapi	"	"
"	Cube	"	"
"	Cube de almidon	"	"
"	Cubi	"	"
"	Pacai	"	"
"	Sachabarbasco	"	"
L. peckholti Wawra	Timbo boticario	Brazil	Freise, 140; Killip & Smith, 211
"	Timbo peixe	"	Freise, 140
L. rariflorus Mart.	Fai faia noroko	British Guiana	Archer, 40
"	Tataira moira?	Brazil	Killip & Smith, 211
"	Timbo	"	"
"	Timbo cururu	"	"
L. urucu Killip & Smith	Timbo urucu	"	"

Species	Common Name	Country	Reference
L. violaceous	Nekoe	Dutch Guiana	Wehmer, 398
"	Stinkwood	"	"
L. sp.	Haiari	British Guiana	Archer, 40
	Red haiari	"	"
	Wakarococda	"	"

Botany of Lonchocarpus

Lonchocarpus nicou was first described in 1775 by Aublet (41) as Robinia nicou from a plant cultivated in French Guiana. The synonymy (158) is as follows:

> Lonchocarpus nicou DC. Prods. 2: 261. 1825.
> R. scandens Willd. Spec. 3:1134. 1801.
> Robinia nicou Aubl. Pl. Guiana. Franc. 771, pl. 308. 1775.

Killip and Smith (209) give the following description of L. nicou:

> "Shrub or small tree, up to 3 meters high, with a main stem 4 to 8 cm. in diameter, with branches borne near summit, the trunk and the branches becoming scandent with age, the trunk sometimes climbing upon nearby shrubs or trees often to a height of 10 meters; leaves alternate, odd-pinnate, the base of rachis and petiolules thickened, the leaflets opposite (2 to 4, usually 3, pairs), oblong, occasionally lance-oblong or oblanceolate-oblong, 12 to 25 cm. long, 4 to 10 cm. wide (average size about 17 x 8 cm., extremes up to 35 cm. long, 17 cm. wide), caudate-acuminate at apex (tip averaging 2 cm. long), subacute to subrotund at base, entire, coriaceous or subcoriaceous, above dark green, sublustrous, and essentially glabrous, beneath paler, sometimes glaucescent, usually densely covered with straight appressed reddish- or golden-brown hairs, pinnate-nerved, the midnerve sometimes impressed above, prominent beneath, the lateral nerves 7 to 10 to a side, ascending, arcuate toward margin, the venation closely reticulate."

"Aublet describes the inflorescence as:

"'Calix; perianthium monophyllum, turbinatum, quinquedentatum. Corolla papilionacea, purpurea, vexillo amplo, erecto. Pericarpium; legumen longum acutum, gibbosum, glabrum, rufescens, uniloculare, bivalve. Semina tria aut quatuor, subrotunda, compressa, marginibus valvarum affixa.'"

Milsum (253) has described white and black haiari grown in Malaya from material imported from British Guiana as follows:

"White Haiari.--A large rambling climbing shrub, evidently ascending to some height under natural conditions. As the plant grows the stems fall over and trail on the ground. Mature stems smooth, whitish in color; immature foliage reddish-brown. Leaves compound, 12 inches long or more, leaflets 7 or 9, 4 to 5 inches long with a short narrow point at the apex. Upper surface of leaflets dark green, glabrous; lower surface paler green than upper surface, with minute light-brown hair on the veins and reticulations.

"Black Haiari.--An erect shrub-like plant, the stems not falling over and trailing on the ground. Mature stems dark brown to black in color. Leaves compound, 12 to 18 inches long. Leaflets 7 or 9, 5 to 7 inches long, with a prolonged narrow point at the apex. Upper surface of leaflets bright green, glabrous; lower surface paler than upper surface, with numerous minute light-brown hairs.'

Various species of Lonchocarpus are found in different countries and their occurrence has been recorded as follows:

Year	Botanist	Reference
1780	Jacquin	226
1801	Linne	232
1823	Humboldt and Bonpland	186
1825	de Candolle	77
1830	Maycock	252
1832	Don	119
1839	Bentham	54
1843	Tulasne	370
1844	Tulasne	371
1844	Fenzl	136
1844?	Richard	285
1848	Schomburgk	327
1853	Sagra	320

Year	Botanist	Reference
1860	Bentham	555
1859-1862	Martius	251
1862-1867	Bentham and Hooker	56
1864	Griesebach	163
1864	Bentham and Mueller	57
1871	Oliver	257
1889	Maiden	242
1890-1895	Rose	309
1891	Kuntze	227
1892	Köpff	226
1896	Hiern	177
1901	Engler	131
1916	Warburg	394
1920	Rock	307
1922	Ducke	125
1917-1925	Pittier	273
1925	Sampaio and Gusmao	321
1925	Ducke	126
1920-1926	Standley	350
1928	Pittier	274
1929	White	399
1930	Ducke	127
1931	Chevalier	86
1933	Donald	120
1933	Herrarte	175
1933	Ebling	129
1933	Cramp	106
1934	Killip	208
1934	Ives	188

Cultivation of Lonchocarpus

Although the South American Indians have cultivated small patches of cube for fishing purposes for hundreds or possibly thousands of years, only recently has the large-scale production of this plant been undertaken. Reports are available on the growing of cube in Peru, Ecuador, Brazil, British Guiana, Dutch Guiana, Malaya, the Virgin Islands of the United States, Puerto Rico, and the Philippine Islands.

Peru.--At present about 90 percent of the world's supply of cube comes from the eastern part of Peru, and Iquitos on the Amazon is the principal port from which it is exported.

Allen in 1921 (38) wrote McIndoo of the United States Department of Agriculture that cube occurred in Peru at high elevations above the flat inundated country east of the Andes and that it was reported to extend up the eastern slope of the Andes to several thousand feet above sea level. Cube is a low shade-loving shrub which the natives insist bears no flowers. Allen was forced to scour all the shops of Huancayo to obtain 35 pounds of dry root. Makinson (244), American Vice Consul in charge, Callao-Lima, Peru, reported on June 19, 1929, that cube is not produced in commercial quantities and is sold only in small local shops in Huancayo and other Sierra towns. "It appears that the main source of supply of this root is the region about Huanta in the Department of Huancavelica in Central Peru whence it is brought to the market town of Huancayo for sale. Other sources of supply are along the banks of some of the large rivers of the Peruvian Montana. Here it is known as barbasco and used exclusively by the natives as a fish poison."

Killip and Smith (210) found a small plantation of <u>Lonchocarpus nicou</u> at Kimpitiriki, a small mission on the Apurimac River. "The plantation consisted of about 100 plants, placed in irregular rows, with 10 feet or more between plants. Here the plants were slender erect trees, 8 to 12 feet in height, with some of the upper branches scandent. These were said to be 2 or 3 years old, and the roots were used at the end of the fourth year (the roots only in this case, although sometimes the stems also are used)." In the Chanchamayo Valley of Peru, east of the Andes, these writers found <u>L. nicou</u> thriving at an elevation of about 4,100 feet.

Iquitos was found to be the center of cultivation of <u>Lonchocarpus nicou</u> and from there westward this appeared to be one of the commonest of cultivated plants. "The <u>barbascales</u> of <u>Lonchocarpus nicou</u> vary greatly in size from small clearings of 25 to 100 plants, intended to meet the wants of a single Indian and his family, to large plantings of as many as 10,000 trees, the source of supply for a whole neighborhood. This species grows best in fairly open well-drained, sandy soil, and is propagated by means of cuttings, a piece of the stem about a foot long being placed horizontally a few inches below the surface. The cuttings grow rapidly, and at the end of the fourth year the plants may be as much as 15 feet high. In general appearance they greatly resemble coffee plants, the individual leaflets, indeed, having much the shape of the leaves of <u>Coffaea arabica</u>. There is a central main stem or trunk, which in the young stages of growth is erect. Later, if there is a tree trunk available for support, the upper part of the stem may bend toward it and climb upward to a height of 50 feet or more. This accounts for the varying descriptions of <u>cube</u> given during the early part of our trip as a tree and a vine. The roots are usually dug at the end of the second, third, or fourth year. The root system of a single individual is very large; one from a plant 2 years old weighed 3 pounds when fresh and 1-1/2 pounds when dry."

According to a report of the Bureau of Foreign and Domestic Commerce of the United States Department of Commerce (386) dated July, 1931, cube grows best in an acid soil containing humus. The rotenone content of the root varies according to the age of the plant and the altitude at which it is grown. While found in a number of sections of tropical America, it has been obtained in largest quantity in Peru.

According to another report of this Bureau (385) it takes four weeks to properly dry cube. In May 1930 dry cube was quoted at \$550 to \$600 per ton, f.o.b. Iquitos, according to its dryness.

The Field Museum (336) has called attention to the fact that the cube examined by Jones (194) was obtained in 1929 in Peru by the Marshall Field Botanical Expedition, and in 1932 (387) the Bureau of Foreign and Domestic Commerce stated that Peru was the principal source of cube, although insecticidal plants occur in diverse regions of Latin America and are often of an uncertain nomenclature locally. Cavanaugh (81), American Consul at Callao-Lima, Peru, in 1932 advised that the Peruvian Government recognizes cube as a potentially important export crop and is endeavoring to extend its cultivation to the coastal areas. McKee (240), American Vice Consul at Callao-Lima, under date of May 8, 1934, reported that experiments on the cultivation of cube are being conducted at the La Molina Experiment Station.

Ecuador.-- In 1932 the Bureau of Foreign and Domestic Commerce (389) stated that according to unofficial reports Ecuador afforded appreciable yields of cube and that substantial quantities could be supplied American enquirers. Quarton (279), American Consul at Guayaquil, in a report dated March 22, 1933, stated that in eastern Ecuador *Lonchocarpus nicou* is generally called timbo and is used to poison fish, but that there has been no commercial trade in such plants from Ecuador.

Brazil.-- *Lonchocarpus* species grow abundantly throughout the Amazon basin, and Brazil seems destined to become the largest producer of cube or "timbo" as it is called in that country.

Killip (207) in 1932 wrote as follows concerning the growing of cube along the Amazon:

> "Cube is extensively grown under the name 'barbasco' in the upper Amazon country around Iquitos. There are occasional plantings of it in the middle and lower Amazon districts where it usually is called 'timbo'. The plantations range in size from small back yards to many acres, as many as six thousand individual plants having been seen by us in one case. A portion of the stem about a foot long is placed in the ground horizontally. Growth is rapid, and at the end of three years the tree is from six to eight feet high. The plants are set out, generally not in definite rows, in sandy, well-drained clearings, often interspersed with yuca. It does not grow in places subject to periodic inundation of the rise of rivers, and is rarely cultivated at elevations more than 800 meters. The roots are usually gathered at the end of the third or fourth year."

The Commercial Association of the Amazon, located at Manaos, Brazil, has reported from time to time interest in timbo. In 1932 (98) a sample of the roots was sent to a New York firm; in 1933 (101) the Association urged those interested to send in samples of timbo to be tested for rotenone by the color reaction of Durham; and in the same year (100) the sending of samples of timbo requested by German scientists was reported. In 1933 (99) the Association sent to New York twenty bales containing 1,000 kilograms (2,200 pounds) of timbo in order to permit an accurate appraisal to be made of the costs of exportation and its selling price in the North American markets. The report added that 2,000 kilograms (4,400 pounds) of timbo had recently been shipped from Iquitos, Peru, to Germany, France, and the United States.

Seltzer (332), American Consul at Para, Brazil, on September 5, 1933, sent to the Insecticide Division about twenty pounds of timbo, of the species known locally as "urucu" and "macquinho", which was obtained from Mazagao, a town in the State of Para, situated northwest of Belem. Seltzer wrote:

> "The demand for the roots seems to be so great that several firms and individuals have recently started a campaign locally to interest farmers in the cultivation of the species of timbo that will give the largest percentage of rotenone. They have also obtained the cooperation of the government authorities that have formerly prohibited the cultivation of these plants because the natives used them for poisoning fish. An American chemist, who has been in Para for several months for the purpose of obtaining the best yielding species, analyzed numerous plants and decided that the species known as 'macaquinho' gives the highest yield."

According to Ives (188) about ten tons of cube or timbo were shipped from Para during 1933. The export price on this material in April, 1934, was about $430 per metric ton. An extraction plant for obtaining rotenone is said to be in operation in Para.

British Guiana. - According to Howes (182), white haiari is often cultivated by the Arawak and Warrau tribes in the open on sandy and lateritic soils, under which conditions it develops into a straggling shrub. Beckett (51) in 1930 reported that several plants of insecticidal value were being cultivated at the agricultural experiment station of British Guiana. Black haiari (the more valuable of the two varieties) grows more slowly and is more severely attacked by an insect than white haiari. Haiari makes excellent growth under partial shade, this condition being allied to their habit in the forests. "The superiority of haiari (especially the black variety) to *Derris uliginosa* has attracted attention abroad and already shipments are being made possible from material collected in Venezuela." The demand for haiari has made it scarce, and great waste is certain to occur unless some supervision is exercised. Beckett (52) in 1931 reported that cuttings of haiari planted at the Hosororo Experimental Station in the northwest district of British Guiana died, due possibly to unfavorable weather. At the Wauna station, the haiari planted in February 1931 grew, excepting those plants in the unshaded area, which died.

White (400), in a report of the Bureau of Foreign and Domestic Commerce issued in 1931, stated that thousands of cube plants are under cultivation in South America but large supplies of the root were not yet available. Haiari or cube was reported to have been shipped from British Guiana in 1930 to the extent of 100,000 pounds. This same Bureau, in a report issued in April 1932 (388), again referred to the cultivation of black and white haiari in British Guiana. Archer (40) in 1934 stated that the Department of Agriculture of British Guiana has made experimental plantings of black haiari and white haiari at Hosororo. The same information is given by American Vice Consul Demorest (114).

Dash (109), in the Report of the Director of Agriculture for British Guiana for the year 1932, reported that black and white haiari, *Lonchocarpus* sp., became easily established after clearing the bush, and needed only occasional weeding. The white haiari grows more vigorously in the open than under shade, and both thrive better on the sandy soils at Wauna than on the laterite at Hosororo. Five acres of these plants were grown at Hosororo and 4 acres at Wauna. Analyses made at the Rothamsted Experiment Station showed that the percentage of rotenone

in the stems was very small and even in the roots did not compare favorably with that obtained in other poison plants grown elsewhere commercially. Another variety of haiari has been discovered which it is hoped to cultivate.

Dash (110), in the report of the Director of Agriculture, British Guiana, for the year 1933, stated that the percentage of rotenone found in samples of black and white haiari grown in Hosororo and Wauna proved disappointingly low. It is suggested that young plants do not contain a sufficient quantity of the toxic principle for commercial exploitation.

Dash (111), in the report of the Director of Agriculture, British Guiana, for the year 1934, reported that haiari cultivation trials in the Northwest District were continued, both the black and white varieties growing more vigorously in the open than under shade.

Dutch Guiana. - The Amsterdam Koloniaal Instituut Handelsmuseum report for 1932 (71) stated that experimental plantings of black and white haiari were being studied in Demerara. The black variety is the more powerful fish poison and it may likewise be richer in rotenone. Spoon and Rowaan (347) in 1933 reported that six and one-half tons of nekoe root were exported from Surinam in 1932.

Nicaragua. - Ebling (129) reports that in Nicaragua Lonchocarpus latifolius H. B. K. is known as pellejo de toro. It occurs only in a wild state, often in localities difficult of access.

Malaya. - Milsum (253) believes that white and black haiari can be cultivated in Malay. In November 1932 several living plants of both black and white haiari were received by the Department of Agriculture of the Straits Settlements and Federated Malay States at Kuala Lumpur from the Royal Botanic Gardens, Kew, the original source of the material being British Guiana. It is reasonably certain that these plants represent two distinct species belonging to the genus Lonchocarpus. The plants were transferred to the Central Experiment Station, Serdang, in January 1933, and planted in open beds during the following month. "It has so far only been possible to obtain material for propagation of white haiari, the growth of black haiari having been slow. Branches of the former type, pegged down below the soil, root readily and become established without difficulty. Stem cuttings of strong mature wood will root under shade, but insufficient material has so far been available to test this method except on a small scale."

United States and Possessions. - The possibilities of growing cube in the Virgin Islands were investigated by Skinner, 1931, (12, 377); and Lonchocarpus from Brazil is being grown in the Los Banos Economic Garden of the Philippine Islands Department of Agriculture (316). Boyd in 1933 (64) reported that a single attempt to grow cube in Puerto Rico, made at the Isabela Experiment Station about 1931, was unsuccessful. Horn (179), in the annual report of the Virgin Islands Agriculture Experiment Station for 1932, stated that root cuttings of cube (Lonchocarpus nicou) received for trial from the Bureau of Plant Industry of the U. S. Department of Agriculture and from the British Guiana Department of Agriculture, had begun to send out roots at the end of the year. In the continental United States cuttings of cube have been grown in a greenhouse in Washington, D. C., by the United States Department of Agriculture (386), and efforts to grow cube in southern Florida have been made by certain individuals. The outcome of these trials is not known. Bailey (48) in 1916 stated that Lonchocarpus species apparently were not in the trade and were but little cultivated for horticultural purposes. Young (409) in 1934 stated that the United States Department of Agriculture is not able at present to give information concerning the culture of cube, but that on account of the tropical or subtropical nature of the principal rotenone-bearing plants it seems doubtful if they can be grown anywhere in the continental United States.

Pests of Lonchocarpus

Insect Pests. - De Seabra (330) in 1922 recorded the occurrence of *Aspidiotus articulatus* on the leaves and branches of *Lonchocarpus sericeus* H. B. growing on the island of S. Thome. This plant was introduced from West Africa.

Bondar (62) in 1929 stated that *Mataposoma porosum* Marshall n. sp. is found boring in the "imbira de sapo" (*Lonchocarpus neuroscapha* Benth.) in S. Paulo, Brazil.

Plant Diseases. - Stevenson in 1926 (352) listed the following diseases as attacking Lonchocarpus:

Aecidium menyharthi P. Henn. - Rust on leaves of *Lonchocarpus* sp. in South Africa.

Diorchidium manaosense P. Henn. - Dull brown rust pustules on leaves of *L. rariflorus* in Brazil.

Endodothella lonchocarpicola (P. Henn.) Theiss and Syd. - Dull black stromata on lower leaf surfaces of *Lonchocarpus* sp. in Brazil.

Ophiodothella atromaculans (P. Henn.) v. Hoehn. - Black stromata on both leaf surfaces of *Lonchocarpus* sp. in Brazil.

Phyllachora lonchocarpi Pat. and Har. - Tar spot on leaves of *Lonchocarpus* sp. in the Congo.

P. lungusaensis P. Henn. - Dull black stromata on leaves of *Lonchocarpus* sp. in Tanganyika.

Ravenelia bakerians Syd. - Brown rust pustules on leaves of *Lonchocarpus* sp. in Brazil.

R. lonchocarpi Lagh. and Diet. - Cinnamon-brown rust pustules on leaves of *L. campestris* and *L. latifolius* in Brazil, Cuba and Guatemala (p. 103).

Use of Lonchocarpus as a Fish Poison

As early as 1725 Sloane (337) mentioned the use of timbo for intoxicating fish and described the use of *Inecou* (*Lonchocarpus*) as follows:

> "Christofle D'Acugna, in his Relation of the River of the Amazons, makes mention of a Wood called Inecou, made use of by the Indians Galibis and those of Cayenne, of which, if Sticks be made broad at the ends, and the Surface of the Ponds beaten therewith, the Fish grow drunk with the Noise, or rather Quality of the Wood, that they rise up dead, and Suffer themselves to be taken with the Hand by the Indians, which I believe may be by the Wood of this Tree." (p. 40).

Aublet (41), who was the first (1775) to describe *Lonchocarpus nicou*, states that the plant was used in French Guiana as a fish poison under the name "nicou." Schomburgk (327), in his travels in British Guiana, 1840-1844, observed various fish-poisoning plants, including the *Lonchocarpus densiflorus* Benth., with the milky pungent root juice of which the natives stupefy fish.

> "When the Indians want to carry out a poisoning expedition, they smash and squash up the roots beforehand with huge wooden clubs and throw the mass into the water at those spots where they notice the fish to be plentiful; in about 10 to 15 minutes its effects are

are visible upon the scaled denizens. They rise to the surface, spring out of the water, gasp for breath, and then turn belly upwards, in which condition they are caught by hand or shot with the arrow. The small finger-long fry usually die while the larger fish generally recover after a time. Besides the Lonchocarpus densiflorus the Indians also use for the same purpose the Tephrosia toxicaria, T. cinerea Pers., Phyllanthus conami Sw., and Clibadium asperum DeC.; none of these plants shows itself as effective as the Lonchocarpus." (260; vol. 1, p. 272).

"That the poison not only acts upon the respiratory organs as can be recognized from the difficulty in gasping for air and widely opened gill-covers, but that it affects the nervous system an equal degree is shown by the generally dilated pupils of the dying fish. Although the giant Sudis gigas appears to be fairly plentiful in these waters, the amount of poison must nevertheless be too infinitesimal for its respiratory and nervous system, because I never succeeded in gaining possession of one of these monsters by this means." (260; vol. 1, p. 319-320.)

Wallace in 1853 (393) gave the following account of fish poisoning in Brazil:

"When the water gets low and leaves pools among the rocks many fish are caught by poisoning the waters with a root called timbo. The mouths of the small streams are also staked across and large quantities of all kinds are obtained. The fish thus caught are very good when fresh but putrefy sooner than those caught in weirs or hooked."

Rosenthal in 1862 (310) listed Lonchocarpus densiflorus, maculatus, nicou, and violaceus as fish poisons.

Bates in 1863 (50) described the catching of fish in the Amazon River with timbo as follows:

> "There was a mode of taking fish here which I had not before seen employed, but found afterwards to be very common on the Tapajos. This is by using a poisonous liana called Timbo (Paullinia pinnata). It will act only in the still waters of creeks and pools. A few rods, a yard in length, are mashed and soaked in the water, which quickly becomes discolored with the milky deleterious juice of the plant. In about half an hour all the smaller fishes, over a rather wide space around the spot, rise to the surface, floating on their sides, and with the gills wide open. The poison acts evidently by suffocating the fishes; it spreads in the water, and a very slight mixture seems sufficient to stupefy them. I was surprised, on beating the water in places where no fishes were visible in the clear depths, for many yards round, to find, sooner or later, sometimes twenty-four hours afterwards, a considerable number floating dead on the surface."

Ernst in 1881 (133) listed 60 fish-poisoning plants, including Lonchocarpus densiflorus and L. nicou. Bois enivrant (Labat) and Heierri (Appun), now known to be species of Lonchocarpus are also listed.

Thurn (365) in 1883 described fishing among the Indians in Guiana as follows:

> "Let us suppose that the Indian hunting party is ready to start. If fish is sought, these are obtained either by poisoning some creek or side stream, or by shooting them with arrows, by netting, by fish traps, or by hook and line. The first is, however, the chief, as it is the most picturesque, mode of fishing.
>
> "A suitable creek or an inlet from a larger river having been chosen, a dam is built across the mouth of this, to prevent the fish which happen to be within the creek from passing back into the main river. Sometimes the dam is made merely by heaping stones and earth; but more often a number of straight stakes are tied together, parallel to each other, as are the laths of a venetian blind, and the palisade thus produced is fastened across the mouth of the stream. Roots, stems, or seeds of plants are then beaten until the fibres are loosened, and these are put into the stream at a point some distance above the dam. The narcotic juices of these particular

plants saturate the water, and stupify but do not kill the fish. Along the banks the Indians stand watching. Before long a few tiny fish rise to the surface, gasp, leap out from the water, fall back into the stream, turn on to their backs, and at last float motionless down the stream. Gradually larger and longer fish show similar signs of discomfort. They dart quickly down the stream, trying to escape out of the poisonous water which surrounds them; then, checked by the dam, they turn, struggle violently, and in a little while they too float motionless on the water. If there are many fish in the creek, the water gradually becomes white with their upturned sides. Meanwhile, the Indians on the bank busy themselves in shooting such of the large fish as might in their struggles escape over the dam, and in collecting those which are already motionless. Very large quantities of fish are often procured in this way, and these, in spite of the poison, are in no way unfit for food. Of the small fish which are left in the water, the very smallest die, but the others after a time recover from their stupor, and remain to restock the stream.

"The fish-poisons most generally used are the roots of the haiari (Lonchocarpus densiflorus), the seeds of the connami (Clibadium asperum Dec.). Less common poisons are the haiari-balli of the Arawaks (Mullera moniliformis), and the yarro-conalli of the Macusis (Tephrosia toxicaria), and many others."

In an account of British Guiana exhibits at the Colonial and Indian Exhibition at South Kensington held in 1886 (1) it is stated that haiari root, Lonchocarpus densiflorus, is one of the most common fish poisons.

Radlkofer in 1886 (281) listed 154 fish-poisoning plants, including the following species of Lonchocarpus: densiflorus Benth., floribundus Benth., latifolius Kunth., nicou DC., and rariflorus Mart.

Geoffroy in 1892 (143) recorded having witnessed in Guiana the use of the milky juice from Lonchocarpus nicou by the natives for stupefying fish. White crystals (which we now know as rotenone) isolated from this plant were toxic to fish at a concentration of 1/10 mg. per liter (1:10,000,000).

Greshoff (158, 160, 161, 162), in his compilations of fish-poisoning plants, lists the following species of Lonchocarpus: densiflorus, floribundus, ichthyoctonus, latifolius, nicou, peckolti, rariflorus, rufescens, and violaceus.

Quelch (280) in 1894 reported on fishing in British Guiana as follows:

> "There are easy methods in use by which the native people secure all varieties of fishes in almost unlimited quantity. The smaller fishes, like the dares, are easily secured by throwing pellets of the crushed leaves of the connami plant (Clibadium asperum) into the water. The fishes greedily devour the pellets, and being narcotized float helpless on the surface, and are rapidly picked up by the Indians ere the effect passes off, and are either used for bait for longer fishes or directly themselves for food."

> "On a much larger scale enormous quantities can be obtained by poisoing the water by means of the fish poison or 'haiari'. The haiari plants are cut into short pieces and pounded into pulp, and then mixed with water, so that the milky poisonous juice might the more readily be dissolved out. By casting this mixture into a stream or channel of the river that has been dammed up to prevent the rapid escape of the water, all the fishes in the immediate vicinity are affected and float after a time, according to their size, either quiescent or struggling on the surface. The larger kinds are rapidly killed or stunned by blows on the head and the desirable ones quickly secured. In this way hundreds of specimens of all sorts may be secured. It is a very effective but wasteful method, since it leads to the wholesale slaughter of large and small fish, the greater part of which is never secured."

Coudreau (105) in 1895 wrote an account of his travels in French Guiana during 1887 to 1891. In this book he recorded the observation that fish in creeks are intoxicated with salisali, counami and coutoupou. Salisali is nicou. It stupefies but does not kill the fish except in the middle of summer when the water is very low.

Penard and Penard (263) in 1907 wrote (translation): "The most powerful fish poison used by the natives of Dutch Guiana is the nekoe (Lonchocarpus densiflorus), a liana which grows principally in the virgin forests. Some of it is as thick as a man's thigh. Both in the dry form and when fresh it contains a poison called nekoline which paralyses fish. * * * * Besides nekoe, the Indians use other poisons, which in general are not so powerful as it is. Among these are koenamie (Tephrosia toxicaria), the leaves of which are used. * * * * The tapir is said to be responsible for the discovery of some of the fish poisons, among them nekoe. It is claimed that this animal ate the leaves and vomited them into the water. Soon the fish were driven to the surface, where he caught and ate them." (p. 120-121.)

Pammel in 1911 (260) mentions Lonchocarpus as a fish poison and includes six species in a catalog of the poisonous plants of the world.

According to the United States Dispensatory, 21st ed., 1926 (406), the wood of Lonchocarpus violaceus (Jacq.) H. B. K. is called stinkwood and is said to be used by the natives of Surinam as a fish poison.

Killip and Smith (210) have given an interesting account of the use of Lonchocarpus nicou for catching fish in one of the streams emptying into the Huallaga in eastern Peru.

> "Such an affair is an occasion for gayety and excitement. An arm of the stream or a small lagoon where the current is not swift is chosen and on the appointed morning two or three hundred people assemble. Some come from considerable distance, afoot or by canoe. The canoes are substantial craft made of a single tree trunk capable of carrying several people.
>
> "Some participants bring large baskets of barbasco roots, others who are less provident come empty-handed to enjoy the fun or to get an undeserved share of fish. Many families make temporary camps along the shore, and everyone is in good humor. The barbasco is chopped into small pieces with a machete and several basketfuls are emptied into each canoe. It is then covered with water until the canoe is about a quarter full. The men and boys tread this mixture with their feet until it becomes grayish white in color. Evidently it has no effect on external abrasions; in fact, it is sometimes taken internally in small amounts as medicine.

"When all is ready the canoes are distributed over the proposed area and at a signal each participant empties his mixture into the lagoon with a calabash. The barbasco left in the bottom of the canoe can be mixed with more water and a second somewhat weaker solution formed. Gradually the quiet water takes on a milky tinge.

"After a few minutes, small fish appear on the surface, struggling in an inebriated manner. These are neglected by the fishers and soon float quietly in death; this careless slaughter of innumerable young fish is the chief objection to the use of poisons. Soon the larger fish are affected; the dying struggles of these cause considerable excitement and rivalry. Canoes are propelled to and fro across the agitated lagoon, each with one or more spearsmen in the bow. The spears, equipped with two or three metal prongs, are jabbed into the fish, which are dextrously flipped into the canoe one after another. Shouts of laughter and encouragement fill the air; both paddlers and spearsmen enter into the competition, and many prizes are stolen from beneath the spear of a friendly rival. Along the shores, children emulate their elders by jabbing the neglected small fry.

"After a few tense minutes the lagoon is 'cleaned out'; only the very large and wary fish are left, the poison having become too diluted to do much further damage. The precise effect of the poison is not known, but it is apparently external. In some ways the gills cease to function, and the fish act as though paralyzed. Some observers have noted a dilation of the eyes. A fish which is only partly paralyzed, upon being placed in fresh water, will often recover.

"Gradually the assemblage disperses, with the prospect of a few hearty meals in the near future. It is said that fish thus obtained can not be kept as long as those otherwise caught, but they are unharmed for immediate consumption. Usually the catch is too large, and the ensuing waste is another score against this method."

Spies in 1933 (342) tested the action of acetone extracts of several plants (1 cc. of extract = 0.2 gram material per liter of water) on goldfish. The seeds of a plant from Puerto Rico which was stated to be Lonchocarpus sepium, but which is the well-known Gliricidia sepium (Jacq.) Steud., were without effect after seven hours' exposure. The roots of Lonchocarpus velutinus from Peru killed the goldfish in 148 minutes as compared to 92 minutes for derris root known to contain 1.7 percent rotenone. Results of tests with barbasco and callo de barbasco, both unidentified plants from Guatemala, are also recorded.

According to a circular of the Department of Agriculture of Peru issued in 1933 (Weberbauer, 397), the roots of Lonchocarpus nicou (Aubl.) DC. are used in Peru as a fish poison. A recent account of fish poisoning by cube is that of Williams (403), which is apparently based on the report by Killip and Smith (210).

> "Several species of trees, shrubs and herbs possessing toxic properties serve this purpose, but the most powerful and generally used one is an evergreen shrub (Lonchocarpus nicou) of the pea family. In Peru this shrub is known as barbasco, a general term for fish poisons in Spanish America, or as cube (pronounced coo-bay). In Surinam it goes by the name of nekko and in British Guiana is called haiari. This shrub, which after three or four years becomes a semi-climber, occurs wild but is also cultivated. It appears to flower seldom. Propagation is obtained by planting pieces of the stem.
>
> "The roots, measuring up to ten feet in length, contain a large quantity of highly poisonous latex. Its use as a fish poison is prohibited by law, but in areas remote from administrative authorities, this primitive custom persists among both Indians and Peruvians.
>
> "Roots from two to four years old are used. These are ground to a creamy pulp. An alternative method is to cut the roots into small pieces, place them in a canoe, and cover with water. The fishermen then stamp on the mixture with their feet until a grayish liquid is produced. A lagoon or stream with little or no current is selected. Across it is built a weir of strong straight stakes and palm leaves, to form a pool into which the barbasco is thrown. After a few minutes the poisoning or paralyzing effect upon the fish becomes apparent. The smaller fish rise to the surface and die. Soon the larger fish are affected. They may be seen jumping out of

the water and the fishermen secure them in outspread palm leaves, in nets or by spearing them. Curiously enough, the poisoned fish may be eaten with perfect impunity."

Use of Lonchocarpus in Medicine

According to Reutter (284) the bark of Serjania (Paullinia) curassavica Radlk., under the name of ecorce de timbo, is used in Central America in popular medicine on account of its content of timboine, and Lonchocarpus violaceus H. B. K. and L. peckolti Wawra are used as a purgative. The leaves of L. latifolius H. B. K. are stated to be purgative (123).

Rosenthal (310) in 1862 compiled information concerning the use in medicine of four species of Lonchocarpus, and Dragendorff (123) in 1898, in his compilation of medicinal plants, listed seven species of Lonchocarpus.

Steyn (353) in 1929 reported that the natives of northern Rhodesia use Lonchocarpus capassa Rolfe (also given as L. capensa Rolfe, 354) as a remedy for snake bites. According to Watt and Breyer-Brandwijk (396) the root of this species is burnt and the smoke inhaled by the Thongas to relieve colds.

De Ficalho (137) in 1884 reported that decoctions of the root of Lonchocarpus sericeus H. B. K. are used in Portuguese Africa for washing wounds and as an antiscorbutic.

Freise (140) in 1931 described the essential oil of Lonchocarpus peckolti Wawra and stated that an investigation of Brazilian anthelmintics showed about 11 percent of them to contain Lonchocarpus oil as the active component.

Killip and Smith (210) in 1931 reported that a mixture of fresh cube sap and water is sometimes taken internally as medicine by the natives of eastern Peru. This mixture has no effect on external abrasions.

Camilloni (74) in 1934 reported that cube was introduced in human medicine by the Laboratorios Maldonado of Lima, Peru, in 1931. Two preparations are manufactured by these laboratories, namely "Sarnol" and "Piojol". Sarnol is intended to cure mange (sarna) and according to reports from Peruvian physicians has proved effective not only in simple cases but also when the disease is accompanied by oedema, and even oliguria, dyspnoea and pyodermia. Results of the application of the remedy are apparent from the first day and a complete cure is obtained after the fifth to sixth day of the application. Piojol

(derived from piojo = louse) destroys lice and also their eggs and has given splendid results in the army and also among civilians.

Pharmacology of Lonchocarpus

Rosenthal (310) in 1862 stated that the seeds of *Lonchocarpus maculatus* DC are used to poison rats and mice.

Rose (309) in 1890-1895, in reporting on plants collected in Sonora and Colima, Mexico, by Dr. Edward Palmer, stated that the seeds of a species of *Lonchocarpus* resembling *L. rugosus* are sometimes eaten by birds but with poisonous effects.

Lanessan (230) in 1886 described *Lonchocarpus latifolius* Kth. from French Guiana as having leaves that are irritating, purgative, emetic, and that poison fish.

Von Sobieranski (341) in 1890 reported pharmacological tests with timboin which was extracted from timbo (*Paullinia pinnata*) according to the method of Pfaff (269). In view of the use of the word timbo in Brazil to designate any fish-poisoning plant, including *Lonchocarpus nicou* and other species of *Lonchocarpus*, it is possible that von Sobieranski's timboin ($C_{27}H_{26}O_8$ according to Pfaff) was impure rotenone. He administered timboin to fish by injections and by addition to the water in which they swam, to frogs by injection (alcoholic solution), and to rabbits and dogs through the stomach (gum suspensions). It was concluded that timboin is a nerve poison which shows no convulsive effect in cold-blooded animals but does produce this effect in warm-blooded animals and soon causes paralysis.

Geoffroy (143) in 1892 tested a colloidal suspension of rotenone crystals which were extracted from *Lonchocarpus nicou*. This suspension was made by adding an alcoholic solution of the crystals to water. Hypodermic injection of this opaline solution into frogs and rabbits caused a progressive and rather rapid slackening of the heart and at the same time an excitability of the medulla.

In 1895 Geoffroy (144) reported the results of additional tests with this plant. A boy who was in charge of the grinding of dried stems of *L. nicou* became very ill from breathing the powder scattered in the air. Pharmacological tests with nicoline (= rotenone) were made upon rabbits, guinea pigs, mice, rats, dogs, pigeons, frogs, tadpoles, fish, crabs, leeches, and insects (flies, wasps, cockroaches, and mosquito larvae). In general the symptoms described by Geoffroy agree very closely

with those observed by Haag (Jour. Pharmacol. and Expt. Ther. 43: 193-208. 1931) in his study of rotenone.

In 1896 Boinet (61) made additional pharmacological tests with nicouline (= rotenone) obtained from Geoffroy. The results were as follows:

1. Nicouline acts on the nervous system, which is often found congested. There is short excitation, characterized by convulsions, increase in respiration and heart rate, slight constriction of the pupils, these lasting for a few minutes. The excitation is marked in fish, frogs, rats, guinea pigs. The duration of the excitation depends upon the dose. The symptoms can be repeated by the repeated injection at ten-minute intervals of 2 mg. in rats and guinea pigs.

2. With large doses, some depression, incoordination, "swimming" movements of the legs. Crabs, lizards, frogs, rats, guinea pigs all are made to resemble automatons.

3. As stupor increases animal becomes paralyzed, but there is no curare effect. With sublethal dose this state lasts several hours. Death may be preceded by convulsions.

4. Ability to respond to sensory stimuli persists to feeble degree until the end.

5. Dilation of the pupil appears along with the stupor, and becomes very marked in the last period.

6. Corneal reflexes are the last to disappear.

7. Rectal temperature of rats and guinea pigs may fall to 30° C. or 25° C., and even 19.8° C. Extremities become cold, and often cyanotic.

8. The action of the drug may be upon the medulla.

9. The substance causes salivation and emesis in the dog. Also frequent and abundant urination. Urine becomes cloudy upon heating.

10. At first respiration is rapid (rate 100 per min.), then superficial and light, later difficult, noisy, with apnea, rales. At last the rate becomes very slow (four a minute).

11. Heart rate is first accelerated, then becomes slow and irregular, with numerous stops. The heart stops in systole.

12. Experiments upon the frog web showed that the substance could cause stasis in the circulation in the web.

The minimal fatal dose for mammals is 1 mg. for each 8-10 gms. bodyweight equivalent to 100 to 125 mg. per kg. bodyweight. Crabs, lizards, and frogs resist doses four times as great.

The substance is rapidly eliminated, as evidenced by the finding that 2 mg. can be given every 10 minutes to guinea pigs (300 gm.) and rats (240 gm.) to a total dose of 3 centigrams, with recovery.

The substance has been used clinically by Heckel in amounts of 1 mg., to cause depression in a case of severe tetanus, but the dose used was insufficient.

In 1911 van Hasselt (171) published a paper entitled "Uber die Physiologische Wirkung von Derrid, Pachyrhizid und Nekoe," but no experimental work with the last-named substance was reported. Nekoeid is stated to be nicoulin, which is now called rotenone.

Steyn (353) in 1929 and again (354) in 1934 reported that a rabbit dosed with 30 gms. (drenched per stomach tube) of dry leaves of Lonchocarpus capensa Rolfe developed no symptoms of poisoning.

Gstirner and Hunerbein (165) in 1933 reported tests with barbasco root and bark of unknown botanical identity. With the root came the information that it occurred in Peru, where it was known as cube, but an examination showed the absence of rotenone. The barbasco bark caused rather serious effects upon those handling it. The insecticidal effect of the root on house flies was very much less than that of pyrethrum.

Knight (215) in 1933 reported the results of tests by Gersdorff which showed that the extract from cube leaves at a concentration of 200 parts per million (based on weight of original material) was only slightly toxic to goldfish.

Chemistry of Lonchocarpus

Martin (250) in 1877 examined the bark of the root of timbo grown in Brazil and isolated an alkaloid called timbonine, starch, a resin, an essential oil, chlorophyll, tannin, an organic acid, and traces of glucose. The alkaloid was extracted with carbon disulphide. Its sulphate was white and crystallized in needles. Martin identified timbo as *Paullinia pinnata*, and from the fact that he found an alkaloid in it his timbo was probably not *Lonchocarpus*.

Rawson and Knecht (282) in 1888 found 0.51 percent indigotin in the leaves of *Lonchocarpus cyanescens* from Africa, and Perkin (266, 267) mentions the use of this plant in Sierra Leone and in northern Nigeria for the manufacture of indigo.

Pfaff (269) in 1891 isolated from Brazilian timbo (which he identified as *Paullinia pinnata* L.) two compounds, a nitrogen-free body called "timboin" and an oil called "timbol." Timboin, melting point 83° C., is very readily soluble in ether, alcohol, benzene, acetic acid, toluene and carbon disulphide, very soluble in chloroform, very difficultly soluble in petroleum ether, and quite insoluble in water. The formula of timboin is given as $C_{27}H_{26}O_8$. Pfaff's timboin was probably impure rotenone ($C_{23}H_{22}O_6$).

Geoffroy (144) in 1895 reported the results of a chemical examination of *Lonchocarpus nicou* from French Guiana, a preliminary report of which was made in 1892 (143). By extraction with petroleum ether a yellowish-white product was obtained, and on recrystallizing this from 90-percent alcohol white crystals (m. p. 162° C.) called nicouline resulted. The solubility of nicouline in 90-percent alcohol, carbon disulphide, chloroform, ether, acetone, benzene, amyl alcohol, petroleum ether, boiling water and cold water was determined. Nicouline occurs to the extent of 2 to 2.5 percent in the large stems of *Lonchocarpus nicou*. Only small quantities are found in the young stems and young branches and only traces in the leaves. Roots were not available to Geoffroy for analysis. Geoffroy's nicouline is now known to be identical with the rotenone from derris root.

The actions of sulphuric, nitric, and hydrochloric acids, of sulphuric acid in the presence of oxidants, of caustic potash and of bromine on nicouline were determined. Analysis of nicouline gave C = 65.38 percent and H = 6.80 percent, corresponding to the formula $(C_3H_4O)_n$. (The formula of rotenone is $C_{23}H_{22}O_6$.) The following color reactions of nicouline were observed by Geoffroy: A drop of concentrated sulphuric acid produces a yellowish-orange color that disappears after several hours; a larger quantity of acid produces a poppy-red which lasts much longer than the orange color. Nitric acid, either ordinary or fuming, immediately colors nicouline a blood red. Caustic potash turns nicouline a pale yellow. Bromine vigorously attacks nicouline, yielding yellow crystals which produce an intense blue color when touched with a drop of sulphuric acid.

Pool (275) in 1898 reported an examination of the Surinam fish poison nekoe or tiengi hoedoe (stinkwood). Nekoe is the stem of <u>Lonchocarpus violaceus</u> Benth. From the alcoholic extract there were obtained nitrogen-free crystals, nearly insoluble in cold water but soluble in nearly all organic solvents. This product was tested on fish, both by subcutaneous injection and by adding it to water containing fish. Pool found the active principle to agree in properties and physiological effect with derrid from <u>Derris elliptica</u>. It is probable that he had an impure rotenone.

Borst Pauwels (63) in 1903 reported an extensive study of nekoe which he believed to be <u>Lonchocarpus nicou</u> DC. and not <u>L. violaceous</u> H. B. K. as reported by Pool. Nekoe is apparently of two kinds, male and female, of which the latter is more effective. By various extraction methods, five materials were obtained from this plant:

1. A crystalline nekoid, rosettes of colorless crystals, melting at 123° C., nitrogen-free, not glucosidal, very slightly soluble in petroleum ether, easily soluble in alcohol, benzene, ether, acetic acid, carbon disulphide and chloroform. Ten milligrams dissolved in a liter of boiling water, but the solution became cloudy on cooling, hence at room temperature the solubility in water does not exceed 1 in 100,000. The action of sulphuric, nitric, hydrochloric, and hydriodic acids is described, and three analyses for carbon and hydrogen are given, from which the composition $C_{32}H_{30}O_9$ is deduced.

2. Beta-nekoid, forming the bulk of the poisonous constituents of nekoe, a light yellow amorphous material, melting at about 82°, nitrogen-free, non-glucosidal, easily soluble in alcohol, benzene, chloroform, ether, ethyl acetate, etc., very slightly soluble in petroleum ether, more soluble in water than the nekoid. Reactions with sulphuric, nitric, hydriodic, and hydrochloric acids are given, as well as combustion analyses. Experiments on acetylization and benzoylization are described.

3. Anhydronekoid, yellow needles, birefringent with parallel extinction, melting point 204°, nitrogen-free, non-glucosidal, not poisonous to fish, slightly soluble in cold alcohol, more so in boiling alcohol, chloroform, ethyl acetate, glacial acetic acid, and acetone. Practically insoluble in water. Gives reactions with reagents mentioned above.

4. A fatty acid, soluble in petroleum ether, melting at 68°, and appearing to be stearic acid.

5. A fatty acid, insoluble in petroleum ether, melting at 74°. Its composition and melting point agree with those of behenic acid, but molecular weight determinations do not.

Physiological tests with fish are reported. The crystalline nekoid in a concentration of 1 to 40,000,000 paralyzed fish in 28 minutes, but a 1 to 10,000,000 solution of beta-nekoid produced the same effect only after an hour.

Several workers have called attention from time to time to the resemblance of the active principles of derris, nekoe, Tephrosia, Pachyrizus, etc. For example, in 1907 Hanriot (170) pointed out that tephrosin, timboin, derrid and pachyrhizide were analogous but not identical, and in 1923 Kariyone and Atsumi (206) compared the crystal form, melting points, compositions and molecular weights of the phenylhydrazones of tubatoxin, rotenone, pachyrhizide and timboin.

Pammel (260) in 1911, in his compilation of information concerning poisonous plants of the world, stated that a very toxic unnamed glucoside ($C_{33}H_{30}O_{10}$) occurs in the bark and root of Lonchocarpus violaceus as well as in Derris elliptica and Mundulea suberosa. This statement is based apparently on the work of Pool, Greshoff, and others.

Tattersfield, Gimingham and Morris (364) in 1926 isolated crystals from alcoholic extracts of haiari (roots of white haiari and stems of black haiari) which were found to be identical with tubatoxin (= rotenone) from Derris elliptica. A resin was also obtained which proved less toxic to aphids.

Von Wiesner (401) in 1927 described derrid as a yellow resinous bitter principle found in the root bark of Lonchocarpus violaceus H. B. K. as well as in Derris elliptica and other plants.

Wehmer (378) in 1929 stated (on the authority of Dragendorff, 123, p. 328) that L. peckolti Wawr. contains the alkaloid timboin. Wehmer has apparently confused the timboin of Pfaff (269) with the timbonine of Martin (250), both of which were derived from timbo identified as Paullinia pinnata.

In 1929 Clark (87) reported finding rotenone, in the Peruvian fish poison cube, later identified as Lonchocarpus nicou by Killip and Smith. Two samples yielded 7.2 and 7.1 percent, respectively, of crude rotenone. After recrystallization from alcohol the rotenone from cube was found to be identical in every way with rotenone from derris root. All of the work leading to the determination of the structure of rotenone has been reviewed by LaForge, Haller, and Smith (229). Later Clark (88, 89, 90, 91, 92, 93, 94, 95) found deguelin and tephrosin and Clark and Claborn (96) found isotephrosin in cube root.

Spoon (344) in 1931 examined two lots of nekoe roots from Dutch Guiana. Nekoe is believed to be Lonchocarpus chrysophyllus rather than L. nicou. One lot of roots which had been on hand for several years was found to contain 7.6 percent ether extract and 2.1 percent rotenone. A second lot of roots collected by the agricultural testing station in Dutch Guiana was found to contain 9 percent ether extract and 2.5 percent rotenone. Deguelin (about 2 percent), tephrosin, and an amorphous red substance were also isolated from these nekoe roots, but no toxicarol was found. Nekoe stems, the so-called stinkwood are of no practical importance as a source of rotenone.

Jones (194) in 1933 reported that the rotenone content of 23 samples of cube root ranged from less than 1 to about 11 percent, average 5.4 percent. This is higher than the average of 2.5 percent rotenone in 45 samples of derris root (range from 0 to 7 percent). A close correlation existed between the rotenone content and the total extractive material (carbon tetrachloride as a solvent) of cube root. There was little or no correlation between these two values in the case of the derris root samples, largely due no doubt to the fact that several species of Derris were represented. A sample of Brazilian timbo root contained about 5 percent rotenone. Analyses of haiari stems and of nekoe stems are also recorded.

Jones (197) in 1933 reported that no rotenone could be detected in several samples of leaves of Lonchocarpus nicou. One sample of stems of this species contained about 0.3 percent rotenone, another sample of large stems contained about 0.1 percent, while a sample of small stems contained no rotenone. Fine cube roots were found to contain a higher percentage of rotenone than the coarse roots. Rotenone is located mostly in the bark and peripheral structure of the root. Various species of Lonchocarpus

(e. g., the roots of L. velutinus, haiari stems, and cipo) from South America were found to contain rotenone. A sample of timbo roots (unidentified botanically) from Brazil contained 16.3 percent rotenone.

Spoon and Rowaan (347) in 1933 reported that three samples of nekoe root from Surinam contained from 8.3 to 9.4 percent ether extract (average 8.8 percent) and from 1.2 to 2.5 percent (average 2 percent) rotenone. Four samples of cube root from Peru contained on the average 12.7 percent ether extract (between the limits 3.8 and 22.7 percent) and 3.7 percent rotenone (between the limits 0.1 and 7.9 percent).

The Amsterdam Koloniaal Instituut Handelsmuseum in 1932 (71) found 1.1 percent rotenone and 7.6 percent total ether extract in a sample of nekoe root obtained from the Agricultural Experiment Station at Paramaribo.

Gstirner and Hunerbein (165) found 7.1 percent ether extract and 9.9 percent chloroform extract in a sample of barbasco root of unknown identity. No rotenone was found. A sample of barbasco bark had 3.4 percent ether extract and 4.8 percent chloroform extract but showed no toxicity to house flies.

According to Freise (140) the fresh roots of Lonchocarpus peckolti Wawra contain an essential oil having 0.158 percent green coloring matter, a strong odor of musk, a specific gravity of 1.0234 at 25° C., and a boiling point of 172° C. Eugenol is one of the components of the oil.

In its annual report for 1933 (72) the Amsterdam Koloniaal Instituut Handelsmuseum mentions that three samples of cube submitted to them were analyzed, but no figures are given.

The Insecticide Division of the Bureau of Chemistry and Soils, during 1933 (215) found rotenone in specimens of the following: Lonchocarpus velutinus, an unidentified species of Lonchocarpus (8.9 percent), timbo root (16 percent), barbasco root, haiari root, and cube stems (0.3 percent). No rotenone was found in cube leaves. A specimen of bejuco de gusano, which may be Lonchocarpus hondurensis, contained 0.4 percent rotenone.

Knight (221) has reported that on long storage of derris and cube roots the rotenone content decreases in some instances but that the total extract remains unchanged. Further work is necessary to prove the point, however.

Jones (199) in 1934 found a new compound in a sample of Lonchocarpus root from Venezuela that gave no qualitative color test for rotenone. This compound $C_{26}H_{26}O_6$ was found to be a monocarboxylic acid with one methoxyl group. Melting points of 201.5° and 220-221° C. were obtained, probably indicating dimorphism. The yield was about 2.3 percent. The pure material is readily soluble in acetone and chloroform, sparingly soluble in benzene and amyl acetate, and only slightly soluble in carbon tetrachloride and petroleum ether. It is optically inactive in chloroform solution. The material crystallizes from amyl acetate in the form of short, columnar crystals with the following refractive indices: $\alpha = 1.510$; $\beta = 1.718$; γ considerably greater than 1.77.

Jones, Campbell and Sullivan (200) in 1935, in a study of Cracca virginiana as a source of insecticidal materials, stated that the samples of Cracca examined contain a much smaller proportion of rotenone-like methoxyl-containing materials than do derris and cube.

Milsum (253) has recently reported analyses of white and black haiari root grown by the Department of Agriculture of the Straits Settlements and Federated Malay States at Serdang. These plants came originally from British Guiana, and the analyses were made about 25 months after planting at Serdang. The air-dry white haiari root contained 11.25 percent moisture and the air-dry black haiari root contained 13.50 percent moisture. On a moisture-free basis the white haiari root contained 7.66 percent ether extract and 0.82 percent rotenone. The black haiari root on the same basis contained 7.92 percent ether extract and 2.97 percent rotenone. Milsum believes that these samples of root were harvested when they were immature and that older root might contain more rotenone.

Chemical Evaluation of Cube

Jones (191) in 1931 suggested the use of carbon tetrachloride for the analytical extraction of rotenone from cube and derris roots in place of ether. Carbon tetrachloride extracts gave a quicker and more selective separation of the rotenone, and in several cases in which no rotenone could be separated from the ether extract, it did separate readily from carbon tetrachloride extracts. The rotenone separates from solutions in carbon tetrachloride as a solvate containing 1 mol of the solvent to one of rotenone. This material can be dried in the air and weighed as $C_{23}H_{22}O_6 \cdot CCl_4$ in which the rotenone content is 71.9 percent. The method is not accurate for samples containing 0.3 percent rotenone or less (Jones, 193). Jones, Campbell and Sullivan (201) have studied the relationships between chemical composition and insecticidal effectiveness of derris, cube and haiari. Three samples of cube gave best results for toxic calue according to the Gross and Smith method for rotenone

and deguelin, one sample of cube and one of haiari gave best results by subtracting from the value of "rotenone" calculated from the methoxyl content of the benzene extract the value for alkali-soluble material. One sample of cube gave equally good results with both methods. The results obtained are shown below:

Sample no.	"Rotenone" based on toxicity	"Rotenone" determined as $C_{23}H_{22}O_6 \cdot CCl_4$	Gross-Smith value	"Rotenone" based on methoxyl minus alkali-soluble
584	10 1/2	4.1	11.0	11.8
674	6	0.8	3.0	5.3
686-A	18	12.1	18.6	18.5
2218-H-1	11	5.6	10.8	14.3
2218-M-1	8 1/2	3.8	9.6	13.3
627	2	0.2	1.4	2.4

The authors conclude: "Results of toxicity to house flies of extracts of 6 samples of derris root, 5 samples of cube root, one sample of haiari stem and one sample of Cracca virginiana root were compared with the values obtained on these samples by certain chemical determinations.

"The amounts of rotenone present in the samples were too low to account for all of the toxicity. In over half of the samples the figures by the Gross-Smith test, considered as representing the sum of rotenone and deguelin, agreed with the toxicity value, but in other samples were lower.

"Total extract values were higher than toxicity, and values based on the methoxyl content of the extract were somewhat closer but were also too high. When an approximate value for toxicarol was subtracted from the methoxyl figures the results agreed more closely with the toxicity figures in general than did the results of other determinations. However, it is impossible on the basis of the present results to unreservedly recommend any one of these chemical determinations as a measure of the insecticidal effectiveness of rotenone-bearing plants. Further work is needed on this subject, particularly along the line of a more thorough study of the individual constituents present in such plant materials."

These conclusions are referred to by Strong (356) in his annual report of the Bureau of Entomology and Plant Quarantine for 1934.

Rowaan (315) has devised a method of determining rotenone in derris root which is equally applicable to Lonchocarpus root. The root is extracted with chloroform and the rotenone weighed as rotenone-carbon tetrachloride solvate.

Tattersfield (361) has reviewed the status of methods that have been proposed for the evaluation of pyrethrum, derris, and cube. The method of Takei for the evaluation of derris by the determination of dehydro compounds has not yet been tested on the several species of Lonchocarpus.

Use of Cube As An Insecticide

Reijne (283) in 1919 reported the results of tests with various sprays against ants, Dolichoderus (Hypoclinea) bidens Latr. Carbolic acid and Phytophiline gave the best results, but the high cost of the latter precludes its use. Nekoe water was useless. According to the Koloniaal Museum of Haarlem (224), Phytophiline is made from nekoe root (Lonchocarpus sp.), but in a letter dated April 7, 1933, the N. V. Maatschappij v. h. Phytobie (272) of The Hague, Holland, manufacturer of Phytophiline and Vitiphiline, denied this and added that trials made with derris root some time ago did not answer to their expectations.

In 1921 Allen (38) wrote McIndoo that cube was used in Peru as a wash for killing parasites and inclosed a snapshot showing the washing of a cow to kill ticks.

McIndoo and Sievers (239) in 1924 were the first to publish the results of careful insecticidal tests with cube. The botanical identity of the material used by them was not certain, but as it was obtained in Peru under the designation "cube" it was undoubtedly a species of Lonchocarpus, and probably L. nicou. In 1929 Killip and Smith (209) traced cube roots on sale in the Huancayo market to the growing plants which were certainly L. nicou.

The following results were obtained by using cube (239 p. 7): The powder used as a dust, was efficient against potato-beetle larvae and four species of aphids (Aphis sp. A and B, A. rumicis, and Macrosiphum solanifolii), but inefficient against Macrosiphum sp. A; used as a fumigant, it was efficient against Macrosiphum sp. C. and the one species of ladybeetle tested; used as an infusion, it was efficient against Aphis rumicis and Macrosiphum solanifolii; used as a decoction, it was efficient but slow against Aphis sp. A and B; and used as a hot-water extract, it was efficient against the same species. Used as a cold-water extract with soap, it had practically no effect on Macrosiphum solanifolii, M. sp. C, and Aphis sp. E.

The cold alcoholic extract of "cube", used without soap, was efficient against silkworms and _Macrosiphum_ sp. _A_; used with soap it was efficient against _Aphis_ sp. _A_, _B_, and _E_, _Macrosiphum_ sp. _A_, _M_. _rosae_, _M_. _solanifolii_, _M_. sp. _C_. _Aphis_ _spiraecola_, _M_. _liriodendri_, and against potato-beetle larvae and sawfly larvae, but inefficient against webworms and the adults of potato beetles; and used with kerosene emulsion, it was efficient against _Macrosiphum_ _solanifolii_, _M_. sp. _C_, and _Aphis_ sp. _C_, _D_, and _E_. The hot-water extract used with soap was efficient against _Macrosiphum_ sp. _A_, but inefficient against _Aphis_ sp. _E_. The benzene extract, used with soap, was efficient against _Macrosiphum_ sp. _A_, and _M_. _rosae_. The dry resin from the powder, dissolved in alcohol and used with soap, was inefficient against _Macrosiphum_ _solanifolii_, _M_. sp. _C_, _Aphis_ _spiraecola_, and _A_. sp. _E_. The filtrate obtained from a cold alcoholic extract which had been concentrated, precipitated in water, and filtered, was practically ineffective against _Macrosiphum_ _solanifolii_, _M_. sp. _C_, and _Aphis_ sp. _E_. The powder of cube, dusted into the hair of three cats badly infested with Mallophaga, was efficient, but the cats became sick from licking themselves.

McIndoo and Sievers (239, p. 23) also tested a water extract of a species of _Lonchocarpus_ on silkworms. It had no effect.

Other fish-poison plants tested by McIndoo and Sievers, namely moetoepoe (or koetoepoe), necotoe and tssikoena, may belong to the genus _Lonchocarpus_. A water extract of the wood of moetoepoe proved to be efficient while a water extract of the leaves was found inefficient against silkworms. A water extract of the leaves of necoetoe killed silkworms very slowly and a water extract of tssikoena had a slight effect against silkworms.

Tattersfield (358) in 1925 reported that extracts from black and white haiari from British Guiana were highly poisonous to aphids. Tattersfield, Gimingham and Morris (364) in 1926 reported that alcoholic extracts of the roots and stems of white haiari and the stems of black haiari (both species of _Lonchocarpus_ from British Guiana) possess notable insecticidal properties when tested on the bean aphis (_Aphis_ _rumicis_ L.). Preliminary experiments indicated that the haiaris when tested as stomach poisons are both repellent and toxic to caterpillars. Crystals isolated from these plants were identical with tubatoxin (= rotenone) from _Derris_ _elliptica_. Tattersfield and Gimingham (362) in 1927 refer to their previous work (364) with white and black haiari and state that the tubatoxin (rotenone) these plants contain is unquestionably one of the most potent insecticides. The authors remark:

"It is interesting that although fish-poisoning plants belong to many natural orders, so far, in our experiments, only those of the order Leguminosae show any marked toxicity to insects. Most of these plants in addition to their toxicity, render foliage markedly repellent to certain biting insects."

Tattersfield (359) in 1927 reported that the roots and stems of both black and white haiari were toxic to Aphis rumicis but that the leaves of both kinds were not toxic.

Gimingham and Tattersfield (148) in 1928 reported the results of laboratory tests with non-arsenical insecticides for biting insects. Extracts of the stems and roots of black and white haiari were extremely repellent to larvae of Orgyia antiqua, Selenia tetralunaria, and Cheimatobia brumata. An extract of black haiari stems was tested on Monima (Taeniocampa) gothica. The insects were slightly affected; there was appreciable feeding but very little growth. Soap, 0.25 percent, was added to all these extracts. Even at high dilution (1 part plant material to 400 parts water) the sprayed foliage remained uneaten and the larvae died of starvation.

Driggers (124) in 1928 made laboratory tests to determine the toxicity of sprays to the eggs of the oriental fruit moth (Grapholitha molesta Busck). An alcoholic extract of cube root at 1 to 200 gave a control of 4.1 percent, at 1 to 500 a control of -0.9 percent, and at 1 to 1000 a control of 1.1 percent. Derrisol plus rosin fish oil soap, 1 pound to 50 gallons, gave a control of 6.3 percent as computed by Abbot's formula. The greatest control, 85.2 percent, was given by Volck at a strength of 1.25 percent. Ginsburg (150) in 1928 tested suspensions and alcoholic extracts of cube root as internal poisons to the honeybee. With the suspension at 1:100, 100 percent of the bees were killed in 24 hours; at 1:200, 100 percent were killed in 48 hours; and at 1:400, 84 percent were killed in 48 hours. An alcohol extract of cube root at 1:250 killed 87 percent of the bees in 48 hours and at 1:500 this extract killed 36 percent in 48 hours. In all cases the bees were fed a 50:50 (by volume) mixture of the solution or suspension with honey.

In a discussion following the reading of a paper by Gibson (146), Ginsburg made the following comments: "Last summer [1927] we tested out cube root which is a very strong fish poison. It killed fish in pools within 15 minutes but it didn't kill mosquito larvae for 24 hours, and then only a small percentage of them. The same material killed larvae in the laboratory within a few hours."

Smith (339) in 1929 and again in 1932 (340) reported tests with insecticides against the California red scale (*Chrysomphalus aurantii* Mask.). Extracts of three species of *Tephrosia* and two species of *Lonchocarpus* (white haiari and black haiari) were added to a highly refined kerosene (viscosity 30 seconds, 98 percent unsulphonatable) and applied as a mechanical mixture with water, no emulsifier being used. These extracts were also added to highly refined spray oils. No combination showed any practical value.

Bishopp et al. (59) in 1930 reported the results of tests with 100-mesh cube powder (rotenone content unknown) against *Hypoderma* larvae in the backs of cattle. All the grubs in eleven cattle were killed following a single application. A mixture of kaolin and derris extract to furnish 2.3 percent rotenone also killed all grubs.

The United States Department of Agriculture (375) in 1930 announced that two to four applications of derris and cube powders at 15-day intervals killed most of the cattle grubs (*Hypoderma* larvae) in the backs of cattle. These powders had no unfavorable effect on the skin and hair of the animals. Killip and Smith (210) in 1931 recorded that in the region of Huancayo, Peru, water treated with cube was sometimes used as a sheep dip.

Pagden (258) in 1931 wrote as follows in reference to citrus fruit borers in the Federated Malay States: "Derris and haiari may be used as stomach poisons for the control of *Citripestis sagittiferella* Moore on citrus." But no experimental evidence was presented.

Davies and Jones (113) in 1932 compared the effectiveness of derris wash (1 pound derris powder, 1/4 pound soft soap, 1 imperial gallon water) and cube wash for the control of ox warbles (*Hypoderma* larvae). The cube root powder tested was obtained from Peru through British Drug Houses, Ltd.

> "Cube root, therefore, while giving a moderately high-percentage kill of warbles, does not appear to be sufficiently reliable in its action when applied at the rate of 1/4 lb. per gallon of wash. Since the main object was to ascertain if any reduction in cost could be obtained, no successful practical purpose could be served by using it at the same strength as derris powder wash. In critical tests where cube root powder wash was used at the strength of 1 b. cube root per gallon, a 100 percent kill was obtained.

"While these experiments show that the toxicity of cube root is sufficiently high to warrant further tests being made on the value of this powder as an insecticide for the control of other pests, they do not justify the inclusion of cube root for the control of warbles so long as derris powder wash gives superior results."

Cavanaugh (81) in 1932, in reporting on the interest of the Peruvian government in cube, stated that experiments with rotenone against insects attacking coco and coffee plants are said to have been successful.

Tattersfield and Gimingham (363) in 1932 reported tests to determine the insecticidal properties of insecticidal plants. Alcoholic or aqueous extracts of finely ground plant materials were diluted with a 0.5 percent solution of nontoxic saponin and sprayed upon the black bean aphis (Aphis rumicis L.) feeding on broad bean plants. Concentrations equivalent to 1 to 5 percent of the plant material were used. Thirty-nine species of plants, including two species of Derris, four species of Tephrosia, and Lonchocarpus latifolius, showed little or no toxicity when tested under these conditions. One specimen of the seeds and pods of Lonchocarpus latifolius from Trinidad showed slight toxicity. Alcoholic extracts of black haiari (Lonchocarpus sp.) were toxic to the young and three-quarters grown larvae of Selenia tetralunaria Hufn. and the one-month old larvae of Orgyia antiqua L. Young larvae of the noctuid moth Monima (Taeniocampa) gothica L. were highly resistant to an old extract of black haiari stems.

Turner (372) in 1932 reported the results of work carried on during 1928-1931, inclusive, with cube extract and with rotenone obtained from cube.

Cube extract was incorporated in a sulphonated mineral oil called "oil-soluble sulphonate" by dissolving the proper amount of cube extract in benzol, mixing this with the oil-soluble sulphonate, and evaporating the benzol at low temperature. This preparation at a dilution of 1-200,000 of total extract of cube killed 37.5 percent of Myzus persicae Sulz. Five months later this preparation gave the same percentage kill, indicating no decomposition of the rotenone in that time.

Cube extract in potassium oleate at 1-50,000 killed 94.5 percent of Aphis rumicis L., but after 18 days' standing the kill at 1-60,000 dropped from 76.1 to 46.7 percent, indicating deterioration of the cube extract within this time.

Cube extract dissolved in mineral oil and emulsified with sodium oleate deteriorated during the five days following preparation. Applications were made at a dilution of 1-250,000 of cube extract against Macrosiphum rudbeckiae Fitch.

Cube extract in mineral oil emulsified with powdered skimmed milk did not decompose on two weeks' standing, a dilution of cube extract of 1-300,000 killing from 68.1 to 74.1 percent of the aphids (Macrosiphum rudbeckiae Fitch).

Rotenone dissolved in oil-soluble sulphonate and applied at the rate of 1 part in 40,000 gave excellent control of Aphis pseudobrassicae on radishes in greenhouses. At the rate of 1 in 50,000 and 1 in 60,000 the results were not so satisfactory.

Cube extract in oil, emulsified with a sulphonate emulsifier, at a dilution of 1-40,000 killed 81.7 percent of Macrosiphum solidaginis, whereas a 40 percent nicotine sulphate at 1-800 killed only 41.2 percent. The following table summarizes the results of other tests with these oil solutions of cube extract:

Results from Use of Cube Extract in Oil on Various Insects

Insect	Emulsifier	Dilution of cube	Dilution of oil, %	Percent killed	Percent killed by check oil
Aphis rumicis	Sulphonate	1-200,000	0.5	80.3	18.5
Malacosoma americana[1]	Sulphonate	1- 50,000	0.5	62.0	12.0
Tetranychus telarius[2]	Powdered milk	1- 12,500	1.0	70.0	14.0
Fenusa pumila[3]	Powdered milk	1- 25,000[4]	1.0	74.0	3.0
Adelges abietis[5]	Powdered milk	1- 25,000[4]	1.0	100.0	100.0
Chionaspis pinifoliae[6]	Powdered milk	1- 25,000[4]	1.0	100.0	5.0
Dialeurodes citri[7]	Powdered milk	1- 75,000[4]	0.33	97.4	79.9
D. citri (eggs)	Powdered milk	1- 50,000	0.5	23.6	10.5
Grapholitha molesta (eggs)	Powdered milk	1- 25,000[4]	1.0	96.4	92.9
Paratetranychus pilosus (eggs)	Sulphonate	1- 25,000	2.0	86.9	89.6
Pteronidea ribesii (eggs)	Sulphonate	1- 25,000	0.5	100.0	12.0
Aspidiotus perniciosus[8]	Powdered milk	1- 12,500	1.0	99.6	96.4
Typhlocyba pomaria[9]	Powdered milk	1- 25,000	0.5	82.0	---

1 Half-grown larvae.
2 Greenhouse test.
3 Larvae in mines.
4 Commercially pure rotenone.
5 Over-wintering females.
6 Half-grown females.
7 Larvae on citrus.
8 Over-wintering females.
9 Nymphs, first brood.

In addition to the tests given above, rotenone in oil was found highly effective in controlling the woolly apple aphid (Eriosoma lanigera), greenhouse mealybug (Pseudococcus citri), rose scale, overwintering scale (Chrysomphalus aonidum Linn.) on greenhouse plants, and hemispherical scale (Saissetia hemisphaerica). Rotenone has not been effective in preventing injury by the plum curculio (Conotrachelus nenuphar), the oriental fruit moth (Grapholitha molesta), or the boxwood leafminer (Monarthropalpus buxi). Tests in controlling the codling moth (Carpocapsa pomonella) were limited owing to low infestations, but in general they showed that rotenone is of some value. On the whole, Turner's tests show that rotenone in comparatively small amounts is valuable as a contact insecticide.

In 1929 preliminary tests were made by Turner to determine the repellent effect of cube extract. Rose plants in the greenhouse were sprayed with emulsified mineral oil containing cube extract at the rate of 1 part in 25,000. Several tent caterpillar larvae (Malacosoma americana Fabr.) were placed on each sprayed plant and suitable check plants. In four tests there was much less feeding on the sprayed leaves than on the unsprayed leaves. The larvae failed to grow on sprayed plants. In one case a sprayed plant was washed twice in four days before larvae were placed on it. These larvae grew normally.

Two series of repellent tests were made on larvae of the imported currant worm (Pteronidea ribesii Scop.). In the first series cube extract at the rate of 1-25,000 caused death of 80 percent of the 20 larvae used within 24 hours, whereas only 15 percent of the 20 larvae on check twigs died. In the second series all the larvae on the sprayed leaves died within 3 days, and 84 percent of the larvae on check leaves died within the same period. The high mortality within a short period of time indicated some toxic action aside from repellent effect.

In a field test some small apple trees received two sprays containing cube extract at the rate of 1:25,000 and 1:12,500. These sprays were applied to kill a heavy infestation of canker worms. The sprays did not kill the worms, but it was noticed that no further feeding occurred on the sprayed trees. The larvae remained on the sprayed leaves for several days, and were apparently normal in reaction to prodding.

In laboratory tests rotenone in mineral oil 1:25,000 killed 78 percent of Colorado potato beetle larvae (Leptinotarsa decemlineata Say) in six days. Arsenate of lead at 1-1/2 pound to 100 gallons (1:555) killed 100 percent.

Rotenone sprayed on potato shoots which were not exposed to sun or rain retained its toxicity for 19 days. Rotenone at 1:5000 was comparable to $HgCl_2$ at 1:1280 in controlling the cabbage maggot (Hylemyia brassicae Bouche).

The Rothamsted Experimental Station Report for 1932 (313) states that the rotenone content of tropical fish poison plants is still the best measure of toxicity. Some samples of these plants are almost devoid of insecticidal power. Some cultivated samples of Lonchocarpus were much poorer than certain wild ones.

Glasgow (154) in 1933 reported the results of spraying the European pine shoot moth infesting red pine in New York with a spray containing 2 percent pine oil and rotenone at the rate of about 1 to 12,800 parts by weight of the spray. A solid cube extract containing 15 percent rotenone was used dissolved in miscible pine oil. According to Glasgow, "A single application of this spray at the right time (July, 1932) appears to give excellent control. The improvement is truly spectacular and can be recognized as far as the plats can be seen."

An anonymous writer (29) in 1933 also described the excellent results obtained against the European pine shoot moth in the nurseries of southeastern New York State by spraying with 1-1/2 pints of cube extract containing 5 percent rotenone oil and 2 gallons of miscible pine oil in 100 gallons of water. The nurserymen are instructed to spray thoroughly between June 25 and July 4, directing the spray branch by branch, downward and inward, so that it may penetrate the needle clusters from the tip toward the base. Two applications, one near the beginning and one near the end of the period named, are advised. It is stated that this treatment has given good results even in severe infestations.

Stahl (348) reported in 1933 that in tests against Ascia rapae L. at Sanford, Florida, a mixture of 1 part derris dust (3 percent rotenone) plus 4 parts inert carrier gave a very good kill. This mixture of approximately 0.6 percent rotenone content gave better results as a contact dust than did a proprietary cube dust supposed to have the same rotenone content.

Chamberlin (82) in 1933 and 1934 found that dusts made by diluting derris or cube powder to a 1 percent rotenone content with tobacco dust or kaolin gave good control of light infestations of the tobacco flea beetle Epitrix parvula Fab. on shade-grown tobacco. Neither derris nor cube caused injury to the foliage even when applied undiluted.

German (142) in 1933 tested the effectiveness of commercial extracts of derris and of cube against the bean aphid, <u>Aphis rumicis</u> L., on nasturtiums. Five commercial rotenone preparations and two commercial pyrethrum-rotenone combinations were tested. It was concluded that the rotenone or pyrethrin content of these preparations should be increased if they are to compare favorably as aphicides with nicotine and anabasine products.

Wisecup (405) compared the relative value of derris and cube, both as sprays and as dusts, against the southern army worm at Sanford, Fla., in October 1933. Small and large larvae were introduced into cages with the following rotenone-containing dusts or sprays on sweetpotato leaves:

Derris spray - 5 percent rotenone - 1 part in 200
Derris dust - 3 percent rotenone, 0.3 mg. per square inch
Proprietary cube extract - 1.6 percent rotenone - 1 part in 200
Proprietary cube dust - 0.57 percent rotenone, 0.3 mg. per square inch

The derris, with the greater rotenone content, appeared somewhat more repellent, showing less feeding at the end of two days, when all larvae were removed to fresh, untreated food. The end results after a week's time were disappointing, as no material had given a kill of over 33 percent. However, the derris gave consistently better kills, both as dust and spray, indicating that the rotenone must be taken into account when recommending a derris or cube product.

Hamilton (169) in 1933 made field tests with derris, cube, and pyrethrum against the gladiolus thrips (<u>Taeniothrips gladioli</u>). A number of different kinds of inert dusts were tested as diluents. Most of these dusts were very light and fluffy and dusted beautifully, but unfortunately the dusts did not adhere to gladiolus foliage or other foliage. A dusting clay manufactured by Hammill and Gillespie of New York had the best properties for dusting and adhering to the foliage. The best control was obtained by dusting once with talc containing 0.5 percent rotenone.

Campbell, Sullivan and Jones (75) in 1934 reported a study of the comparative merits of derris root, cube root, and haiari stems for use as kerosene extracts against house flies. The extracts were prepared by shaking a given weight of the ground plant material with a highly refined grade of kerosene for 7 hours and filtering the next day. Solutions of rotenone in a mixture of cyclohexanone and kerosene were used as standards. Fifty flies were used in each test and they were sprayed with

about 4 cc. of liquid. After being exposed to the settling mist for two minutes they were released in cages for subsequent observation. Counts of dead and moribund flies were made at the end of 1, 2 and 3 days after treatment. Nearly all the flies were paralyzed within about 10 minutes after spraying with the kerosene extracts of derris, cube, and haiari, and the rotenone standard. It was characteristic of the action of rotenone and of the kerosene extracts tested that the flies did not recover from the initial effects, which tended to become greater rather than less. The flies recovered quickly from the slight effect of kerosene and more slowly from the greater effect of cyclohexanone-kerosene.

In order to determine the minimum number of daily counts needed to measure the complete effect of rotenone and of extracts having a similar action, the standard rotenone solution was tested at 1:2000 and mortality counts made for 10 days. It was found that after the third day only a small number of deaths occurred per day and it was decided to make subsequent tests for 3 days only. After preliminary tests of extracts of one of the cube roots it was decided to make extracts for the final tests at 10 grams of root per 100 cc. of kerosene.

Of the plant materials tested, derris roots on the whole yielded the most effective extracts, although the sample of cube root containing 11.2 percent rotenone gave about the same effect as did the best sample of derris. The values for percentage of house flies dead in 3 days ranged in the case of the derris roots from 85.2 to 91.7 percent and for the cube roots from 68.2 to 92.5 percent. The extract of haiari stem was the least effective. Extracts of the derris root containing no rotenone and the cube root containing 11.2 percent rotenone made at 10 grams root per 100 cc. of kerosene were almost equally effective. However, when tested at lower concentrations the cube sample proved to be definitely more effective.

Evidence is given for and against the importance of rotenone in the extracts. Although an effective solution of rotenone in kerosene could not be obtained by merely shaking the rotenone with kerosene as was done in extracting the roots, nevertheless it is possible that the rotenone is more soluble in the presence of the resinous materials in the root. By determining the rotenone content of the marcs left after kerosene extraction of several of the roots it was shown that the kerosene did extract a sufficient proportion of the rotenone to be highly effective. Petroleum ether extracts, which had been shown by other investigators to contain rotenone, were tested at an extract concentration of 1:2000 in comparison with rotenone at the same concentration. None of the extracts proved to be as effective as rotenone.

In tests of alcoholic solutions of the other known components of the roots it was found that deguelin was nearly as effective as rotenone, tephrosin slightly effective, and toxicarol ineffective. After weighing the evidence at hand the writers conclude that rotenone is not the only toxic component of the kerosene extracts tested, although it does play an important part in the effect of the extracts of derris, cube, and haiari on house flies. It is suggested that the methoxyl content may be a better chemical measure of the insecticidal value of these plant materials than the rotenone content.

Lapparent (231) in 1934 tested a mixture of 9 parts potato starch and 1 part derris upon roaches with good results and states that cube may be substituted for the derris which should have a rotenone content of 5 percent.

Fleming and Baker (139) in 1934 reported that cube resin, at either 1 or 2 pounds per 100 gallons, was wholly ineffective as a stomach poison or repellent for the Japanese beetle. The beetles completely defoliated Yellow Transparent apple twigs to which the spray was applied. Rotenone and deguelin are repellent to the Japanese beetle, but toxicarol, tephrosin, and the resinous material from derris appear to be of no value as repellents.

Penick & Co. (265) in 1934 expressed the opinion that while cube may contain rotenone and other toxic constituents in amounts comparable to derris the latter is the more efficient insecticide.

Huckett and Hervey (184 and 185) have reported results of tests with derris and cube made in western New York and on Long Island during 1934. The derris contained 5.3 percent rotenone and 21 percent total extractives. The cube contained 5.1 percent rotenone and 20 percent total extractives.

Dust mixtures containing either powdered derris or cube root, prepared from roots having nearly the same average rotenone and total extractives content, compared favorably in effectiveness with one another when used against cabbage worms. The differences in results obtained with mixtures of 0.5 to 1 percent rotenone content were small and variable, indicating that the weaker strength is satisfactory for practical purposes and for reasons of economy would be preferable to the 1 percent mixture. All were superior in effectiveness to dusts of 0.33 percent rotenone content. Talc, clay, finely ground gypsum, and sulphur-clay were satisfactory diluents or carriers.

Spray mixtures containing derris powder were slightly more effective than those containing cube powder. The sprays were not quite as effective as derris or cube in dust mixtures.

The zebra caterpillar was practically unaffected by applications of derris, cube, or pyrethrum powder.

Likewise cabbage aphids were not satisfactorily controlled by derris or cube dust mixtures. In both instances, however, the pests were conveniently controlled by spot dusting with 3 to 4 percent nicotine-lime mixtures, without interfering with the efficacy of derris or cube treatments for green worms.

Preliminary tests in the use of derris and cube have been made with other insects under field conditions with varying results. Derris and cube spray and dust mixtures at strengths comparable to those used to control green worms on cabbage and cauliflower have shown promising results when applied for the control of thrips (T. tabaci Lind.) on cauliflower seedlings and for the control of the Mexican bean beetle on lima and snap beans. In both instances it was thought best for the sake of effectiveness to apply the dusts during the evening in anticipation of a more or less extended period of high humidity. Neither derris nor cube were satisfactory for use against the corn ear worm.

Chamberlin (83) in 1934 reported the details of laboratory tests on the tobacco flea beetle (Epitrix parvula Fab.). The derris and cube were diluted to a rotenone content of 0.05 percent and the dosage in each experiment was 0.08 gram. The derris dust gave an average of 85.1 percent dead; the cube dust, an average of 85.7 percent dead. A finely ground inert "filter dust" was used as the diluent. Seventy-five beetles were used in each individual test, a total of 3,000 beetles being used in the series of tests. The tests were made as follows:

> "The beetles were first confined within the cages and the dusts then introduced. All beetles were subjected to the dust cloud which soon settled on the sides and floors of the cages. The more active individuals crawled or hopped about more extensively than the others and in this manner collected relatively greater amounts of the dusts. This introduced unavoidable variations in the mortality. When the series of twenty individual experiments is considered as a single unit this factor is largely eliminated. Observations showed that the mortality was due mainly to the clean-up habit induced by the irritation of the dusts. The death rate in the checks was considered negligible."

Chamberlin (84) reported that in 1934, at Quincy, Fla., both derris and cube diluted to a rotenone content of 1 percent by admixture with tobacco dust or kaolin gave good control of the tobacco flea beetle (Epitrix parvula Fab.) on tobacco in tobacco plant beds. The infestation was light. Neither poison injured the foliage even when applied undiluted. Derris and cube dusts containing 0.75 percent rotenone rid newly set tobacco in fields of overwintered flea beetles.

Field tests upon maturing tobacco indicated that a dust containing 0.75 percent rotenone, applied at the rate of 8 to 10 pounds per acre, is effective in controlling flea beetles when the infestation is light. As diluents for derris or cube the following were tried: Georgia clay, talc, celite, and a tobacco dust 80 percent of which passed through a 150-mesh screen. The last is the most suitable for shade tobacco dusting. Derris applied at the rate of 8 pounds per acre killed 94.8 percent of the flea beetles and cube applied at the rate of 7-1/2 pounds per acre killed 83.2 percent of the beetles. Both powders contained 0.75 percent rotenone.

R. E. Campbell (76), at Alhambra, Calif., in 1934 found that in cage tests derris dust killed 51 percent of pepper weevils as compared to 54 percent for cube dust. Both dusts contained 1 percent rotenone.

Field tests were made at San Fernando, Calif., on March 29, 1934, with derris and cube dusts containing 0.5 percent rotenone on cabbage. Applications were made at 22 pounds per acre for derris and 30 pounds per acre for cube by means of hand dusters. In numbers of loopers, derris caused a reduction of 75 percent and cube of 34.4 percent; derris destroyed 54 percent of cabbage worms as compared to 47.7 percent for cube, and derris destroyed 58.6 percent of the diamond-back caterpillars as compared to 60.5 percent for cube.

Cassidy and Barber (78) during 1934 made tests with certain insecticidal dusts against 5 species of sucking insects found on cotton in Arizona. Tests were conducted in the field by caging cotton plants under cages 3 by 3 by 3 feet and in the insectary by using branches of cotton enclosed in lantern-globes. These tests were replicated from 2 to 4 times. Ten insects were used in the cages and five insects in the lantern globes. After introducing the insects the plants were thoroughly dusted from the outside with a small Root hand gun. Cages were observed for a week and lantern globes for two days. The results of the cage and lantern globe tests are combined in the table. The difference between the percentage of dead insects in the dusted experiments and the checks run with each experiment is used as the "percent control."

Insect	Cube	Derris	Best Insecticide
			Percent Control With:
Stictocephala festina	80	55	95 (pyrethrum)
Lygus sp.	70	80	100 "
Euschistus impictiventris	43	38	43 (cube)
Chlorochroa sayi	0	22	22 (derris)
Dysdercus mimulus	26	10	70 (pyrethrum)

In addition to cube and derris the following were tested: pyrethrum, sodium fluosilicate, lead arsenate, two kinds of flotation sulphur, ground sulphur, and phenothiazine.

Ewing (134) made tests in cages to determine the toxicity of cube to the cotton flea hopper, Psallus seriatus Reut., at Port Lavaca, Tex., in 1934. His conclusions were:

> "The powdered cube root (4 percent rotenone) gave practically no control of either adults (9.7 percent) or nymphs (14 percent). All the tests during the last few years with dusts containing rotenone have shown this insecticide to be ineffective in controlling the cotton flea hopper."

Howard (181) in 1935 reported the results of tests with cube against the Mexican bean beetle, Cube (rotenone = 7.7 percent) at 1-1/2 pounds per 50 gallons, applied at the rate of 118 gallons per acre, gave a 92 percent better control than the check. Derris containing 4.4 percent rotenone gave equally as good results. The addition of 1 pound of Kayso or 1 pound of soap to the cube spray gave about the same result. Both derris and cube sprays gave better control than either magnesium arsenate or synthetic cryolite. A cube powder diluted with talc to a rotenone content of 0.77 percent and applied as a dust at the rate of 21 pounds per acre gave as good results as sprays of magnesium arsenate or cryolite.

Cube (rotenone = 7.7 percent) gave as good results as derris, either as a spray or as a dust for the control of insects on cabbage. As a spray a dosage of 1-1/2 pounds per 50 gallons, and as a dust a 10:90 mixture, is recommended. Howard summarizes the results of tests with derris and cube as follows:

"Derris dust was found to be better than any of the other materials tried for the control of cabbage worms but was not as effective as nicotine for the control of cabbage aphid. Derris root mixed with talc, infusorial earth or tobacco dust so as to contain from 0.5 to 0.75 percent rotenone and used at intervals of 7 to 10 days at dosages of 25 to 30 pounds per acre per application was found to be very effective against the common cabbage worm; fairly effective against the looper and the diamond-back caterpillar, but was not very effective against the zebra caterpillar. Derris dusts were found to be more effective against cabbage worms than derris powder in water but the powder in water was more effective than the derris extract in water used as a spray. Cube root when used either as a dust or in water as a spray gave similar results to derris, providing the rotenone content was the same."

Smith, Clark and Scales (338), at Tallulah, La., in 1934 compared the effectiveness of derris, cube, and other insecticides against the boll weevil, the cotton leafworm, and _Lygus apicalis_ in cages and in the field. Both derris and cube contained 4 percent rotenone. Results are as follows:

Insecticide (applied as a dust - "average field dusting" with a small hand dust gun)	Percent Mortality Boll weevil	Leafworms	_L. apicalis_ adults	nymphs
Cube + kaolin (1:1)	41.7	40.0	14.9	15.5
" + " (1:3)	33.4	14.7	17.3	15.6
" + " (1:7)	34.7	9.4	17.7	22.1
Cube only	75.0	59.7	41.5	44.8
Derris only	91.6	73.3	51.6	41.1
Calcium arsenate	81.8	93.5	33.3	58.6
Check	32.8	1.4	18.8	13.7

As shown in the table, cube was not equal to derris of equal rotenone content in controlling these insects.

Haegele (166 and 383) tested in 1934, at Parma, Idaho, a mixture of 1 part cube powder and 3 parts kaolin (rotenone = 1 percent) for the control of the codling moth. The dosage was either 5 or 10 pounds of the mixture per 100 gallons of water, applied at 7-day intervals (12 applications in all). The trees were about 20 years old and consisted of Rome Beauty, Winesap and Jonathan. Comparative figures for this mixture and lead arsenate, 3 pounds per 100 gallons applied in the regular schedule (8 applications), are as follows:

	Wormy fruit	Fruit free from worms and stings	Worms per 100 apples	Stings per 100 apples
	percent	percent		
Lead arsenate, 3 lbs. per 100 gals., 8 applications	68	2.6	266.9	317.3
Cube mixture, 10 lbs. per 100 gals., 12 applications	98.6	1.0	481.9	16.9
Lead arsenate, 3 lbs. per 100 gals., 8 applications	66.3	2.4	181.6	318.2
Cube mixture, 5 lbs. per 100 gals. + 1/2% white oil, 12 applications	91.3	1.6	304.9	131.8

Although a heavy residue of cube-kaolin was left on the fruits, this did not inhibit coloring.

The derris and cube dusts tended to be somewhat nauseating to the operators.

Childs (383) also tested the cube-kaolin mixture against the codling moth on Yellow Newtown apples at Hood River, Oreg. The results compared with those obtained with lead arsenate are as follows:[1/]

	Fruit free from worms and stings	Wormy fruit	Stung fruit
	percent	percent	percent
Lead arsenate, 3 lbs. per 100 gals., 5 applications	96.4	.7	3.0
Cube mixture, 10 lbs. per 100 gals., 10 applications	94.1	3.9	2.4

Both at Parma and at Hood River, derris-kaolin (rotenone = 1 percent) gave results quite similar to those obtained with cube-kaolin.

1/ Figures slightly revised.

Gentner (383), at Talent, Oreg., tested the cube-kaolin mixture on the codling moth infesting 25-year old Bartlett pear trees. Four cover sprays of lead arsenate were applied following a calyx and first cover of lead arsenate, and 6 cover sprays of cube-kaolin were applied also following a calyx and first cover of lead arsenate. Because of delay in receiving materials, nicotine-bentonite (3 lbs. per 100 gals.) was used in the third cover spray in place of cube-kaolin.

When lead arsenate only was used, 5.6 percent of the fruit was wormy; when cube-kaolin was used as above described, 14.2 percent was wormy; and when derris-kaolin was used, 16.3 percent was wormy.

None of the sprays injured the fruit, but the heavy residue of cube-kaolin prevented uniform coloring of those pears which developed a red cheek. An acid wash containing as much as 3 percent acid at 100° F. failed to remove a derris-kaolin residue on pears, but Robinson removed all traces of the residue by washing in a solution of sodium silicate.

The Bureau of Entomology and Plant Quarantine (384) concludes, from a review of all work done in the United States in 1934 on the control of the codling moth, that mixtures of 1 part cube root with 3 parts kaolin gave unsatisfactory results. The kaolin used as a carrier caused an unsightly deposit on the apples that could not be removed by the usual hydrochloric acid wash and otherwise high-quality fruit could not be marketed except at a cannery. However, Robinson removed all traces of derris-kaolin residue from pears by washing them in a solution of sodium silicate.

Marshall (249), in a review of recent developments for the control of the codling moth, states that derivatives of derris or cube root have so far not been so widely applicable as nicotine.

Chapman and Cavitt (85) reported the following laboratory tests with cube and other insecticides in Presidio, Tex., in May, 1934.

Petri dishes with a small coin placed in the center were covered with a light covering of dust applied with a small hand gun in a dusting chamber. Approximately 25 newly hatched first-instar pink bollworms were placed in the undusted circle which had been covered by the coin and allowed to crawl into the dust. Examinations for mortality were made at half-hour intervals up to 2-1/2 hours time. Four dusted dishes and a check were used for each test.

Series I. - Thirteen insecticides, including several samples of derris from different sources, cube, and pyrethrum, were used. The derris samples contained from 1 to 8 percent rotenone and the cube contained 6 percent rotenone. All the samples were mixed with flour in equal proportions. Pyrethrum showed no kill, "while many of the derris samples and the cube root showed as much as 100 percent kill at the 2-1/2 hours examinations. The checks showed no mortality."

Series II. - The above-mentioned samples were all diluted with flour 1 part to 3 parts in this series. "At the end of 2 hours there were few larvae alive in any of the tests and in one sample there was 100 percent mortality."

Series III. - In this series the two samples of derris that gave the best results in Series I and II and the cube were selected.

Dust No. 1. - Derris claimed to contain between 5 and 7 percent rotenone was mixed with flour 1 part to 7. Diluted dust therefore contained approximately 3/4 percent rotenone. Eighty-six and five-tenths percent of the larvae were dead in 2-1/2 hours.

Dust No. 7. - Derris containing 5-1/8 percent rotenone was mixed with flour 1 part to 7 parts. Diluted dust therefore contained approximately 5/8 percent rotenone. Eighty percent of the larvae were killed in 2-1/2 hours. No mortality in checks during the same period.

Dust No. 12. - Cube containing 6 percent rotenone was mixed with flour 1 part to 7 parts. Diluted dust contained 3/4 percent rotenone. All of the larvae were dead in 2-1/2 hours.

Preston (278) in 1934 reported as follows on the use of cube:

> "In experiments in Peru a suspension of the ground dried roots of cube [Lonchocarpus] in a solution of sodium carbonate proved a successful dip in control of ticks and mange mites on sheep. The treatment protected sheep from re-infestation by ticks for at least a week. Ticks survived for several days on a piece of fleece wetted with the liquid and kept moist, but died in a day on another piece of fleece similarly wetted but allowed to dry. It is therefore concluded that the drying of the wool and the body warmth assist the action of the poison. The amount of sodium carbonate must be varied according to the hardness of the water. Two applications, with a week's interval, of a mixture of 1 part cube powder and 100 parts oil cured mange on llamas."

Steer (351) in 1934 reported the results of experiments on the control of the raspberry and loganberry beetle in Kent, England. Derris and cube were compared. The derris contained 2.71 percent crude rotenone or 2.32 percent recrystallized rotenone and was used at the rate of 2 pounds per 100 imperial gallons of spray. The cube contained 6.26 percent crude rotenone or 5.27 percent recrystallized rotenone and was used at the rate of 1 pound per 100 imperial gallons of spray. In both cases 5 pounds of soap per 100 gallons was added. The cube was less finely ground than the derris, but with constant agitation proved suitable for spraying purposes. As used in the field the derris spray contained 0.0054 percent and the cube spray 0.0064 percent crude rotenone. Steer concluded, "At the concentrations used no differences can be detected between the performances of derris [one application on June 16] and of cube [one application on June 16] either at any one time during the picking season or for the whole period."

McDougall (236) in 1934 reported tests on a limited scale with cube powder for ox warble control in Scotland. Using the proportions 1/4 pound of the powder to 1 imperial gallon of water, 43 warbles were dressed and on examination for results, 25 larvae were dead, 5 larvae were alive and 13 larvae burst in being squeezed out. Using 1/2 pound of the powder to 1 imperial gallon of water, 42 larvae were dressed and on re-examination 30 larvae were dead, 1 larva was alive and 11 larvae burst in being squeezed out for examination.

Worsley (407) in 1934 described tests against citrus aphis with extracts of two species of Lonchocarpus designated "A" and "B".

The results obtained were as follows:

		Percent extract	Percent kill
Lonchocarpus A	Leaves	2	45
		1	25
" "	Roots	2	50
		1	37.5
" B	Leaves	2	37.5
		1	20
" "	Roots	2	42.5
		1	35

Saponin, 1 percent, was used as a spreader in all tests. Nicotine sulphate solution (0.25 percent nicotine) killed 95 percent of the aphids.

The extracts were prepared by adding the dried, ground material to absolute alcohol in the cold at the rate of 1 gram per 9 cc. The mixture was shaken vigorously and left for 24 hours with occasional shaking, after which it was filtered on a Buchner funnel and washed through with sufficient alcohol to bring the volume up to 10 cc. per gram of material. This solu- is referred to as a 10-percent extract of the plant material and on dilution to ten times its volume it becomes a 1-percent extract.

Walker and Anderson (392) in 1935 reported the results of tests made in the Virginia Truck Experiment Station with arsenical substitutes for the control of vegetable crop insects. They concluded that, based on rotenone content, a cube dust did not seem to give quite as satisfactory control of cabbage worms (cabbage looper, Autographa brassicae Riley, and larvae of the diamond-back moth, Plutella maculipennis Curtis) as did a derris dust.

List and Sweetman (232) in 1935 reported the results of tests with derris, cube, pyrethrum, Paris green, cryolite, calcium arsenate and lead arsenate against cabbage worms in Colorado. All applications were in dust form applied with the Root hand duster. Dosage was variable but did not exceed 10 pounds per acre. The diluent was Celite FC, a diatomaceous earth, 5 percent of which is coarser than 150-mesh and 10 percent coarser than 325-mesh. All dusts were prepared by mixing in a ball-mill type mixer 15 minutes. It is concluded that pyrethrum powder containing 0.18 percent pyrethrins, derris powder containing 0.5 percent rotenone, and cube powder containing 0.5 percent rotenone are equally efficient. In another series of tests pyrethrum powder containing 0.18 percent pyrethrins, derris powder containing 0.5 percent rotenone, cube powder containing 0.5 percent rotenone, and a mixture containing 12.5 percent Paris green were all of equal value in the control of Ascia rapae L. A series of tests showed that a dust containing 0.1 percent rotenone was as effective as a dust containing 0.4 percent rotenone. Other series of tests showed no significant difference between dust containing 0.5 percent and 0.4 percent rotenone. No significant difference was found between dusts containing 0.3 percent rotenone and 0.6 percent rotenone. Morning and evening applications of a cube dust containing 0.5 percent rotenone are not significantly different.

Ginsburg and Granett (152) have compared the aphicidal properties of derris and cube root. The derris sample contained 5 percent rotenone and 17.9 percent acetone extractives and the cube root contained 5 percent rotenone and 16.7 percent acetone extractives. The comparison was made in application of dusts, water suspensions, and laboratory prepared acetone extractive. For suspensions and for dusts the root was ground to about 100-mesh. Aphis rumicis on nasturtiums was used for these tests. While there were small differences in favor of derris, the authors conclude that the roots of both plants, provided that they contained approximately the same amounts of rotenone and total extractives, are equally toxic to aphids.

Barfoot (49) in 1935 stated that the cherry and pear growers of the Bay district of California used several tons of rotenone dusts for the control of slugs, aphids and thrips. The greater part of this material was made by mixing cube root powder with kaolin, talc, whiting, or diatomaceous earth.

Miscellaneous references to the insecticidal value of cube are the following:

Huckett (183) in 1933 stated that cube root was being placed on the market in various forms for use as an insecticide (a) as a fine dust with or without a diluent, and (b) as a liquid extract with or without a spreader or sticker. For use against cabbage insects the dusts should contain between 0.5 and 1 percent rotenone.

Hamilton (168) in 1933 stated that powdered cube root has a distinct repellent effect and some fumigating effect against certain plant insects such as plant lice and leafhoppers.

John Powell & Co., Inc., (277) in 1933 discussed derris and cube as insecticides. They believe pyrethrum is more satisfactory for household use.

Strong (355) in a memorandum dated March 14, 1934, discusses the preparation of dusting mixtures made from derris, for which cube can be substituted.

Williams (403) in 1934 reported that the latex from the roots of Lonchocarpus nicou is used in the Andean highlands as a wash to kill ticks on cattle.

Classified List of Insects Against Which Cube has been Tested

Insect and Stage of Development	Preparation	Effectiveness	Reference
Orthoptera			
Blattidae			
Roaches	1 part cube (rotenone = 5%)+ 9 parts potato starch	Effective	Lapparent (231) in 1934
Mallophaga			
Mallophaga on cats	Cube powder	Effective	McIndoo and Sievers (239) in 1924
Thysanoptera			
Thripidae			
Taeniothrips gladioli M. and S. (gladiolus thrips). Nymphs.	Cube powder + talc (rotenone = 0.5%)	Good	Hamilton (169) in 1933
Thrips tabaci Lind. (onion thrips)	Cube spray and dust mixtures	Promising	Huckett and Hervey (184 and 185) in 1934
Thrips	Cube powder + kaolin, talc, whiting or diatomaceous earth	Effective	Barfoot (49) in 1935
Homoptera			
Phylloperidae			
Adelges abietis (spruce gall aphid). Over-wintering females.	Rotenone from cube, 1:25,000, oil 1.0%, powdered milk emulsifier	100.0% kill (100.0% by check oil)	Turner (372) in 1932
Aphididae			
Aphis rumicis L. (bean aphid). Nymphs and adults.	Cube dust	Effective	McIndoo and Sievers (239) in 1924
Ditto	Cube infusion	Effective	Ditto
Ditto	Alcoholic extract of black haiari stems	Excellent	Tattersfield, Gimingham, and Morris (364) in 1926
Ditto	Alcoholic extract of white haiari stems	Excellent	Ditto
Ditto	Alcoholic extract of white haiari roots	Excellent	Ditto
Ditto	Black haiari leaves	Ineffective	Tattersfield (359) in 1927
Ditto	Black haiari stems	Effective	Ditto
Ditto	Black haiari roots	Effective	Ditto
Ditto	White haiari leaves	Ineffective	Ditto
Ditto	White haiari stems	Effective	Ditto

Classified List of Insects Against Which Cube has been Tested

Insect and Stage of Development	Preparation	Effectiveness	Reference
Homoptera			
Aphididae (continued)			
Aphis rumicis L. (bean aphid). Nymphs and adults.	White haiari roots	Effective	Tattersfield (359) in 1927
Ditto	Alcoholic or aqueous extract of Lonchocarpus latifolius + 0.5% saponin solution	Ineffective	Tattersfield and Gimingham (363) in 1932
Ditto	Alcoholic or aqueous extract of seeds and pods of Lonchocarpus latifolius + 0.5% saponin solution	Slightly toxic	Ditto
Ditto	Cube extract in oil with sulphonate emulsifier (cube 1:200,000), oil 0.5%.	80.3% kill (18.5% by check oil)	Turner (372) in 1932
Ditto	Cube extract in potassium oleate, at 1:50,000	94.5% kill	Ditto
Ditto	Cube extract, in potassium oleate, at 1:60,000 (fresh)	76.1% kill	Ditto
Ditto	Cube extract, in potassium oleate, at 1:60,000 (18 days old)	46.7% kill	Ditto
Ditto	Commercial cube extracts	Less effective than nicotine and anabasine products	Garman (142) in 1934
Ditto	Cube dusts, water suspension, and acetone extractive	As effective as derris	Ginsburg and Granett (152) in 1935
Aphis spiraecola Patch (citrus aphid). Nymphs and adults.	Cold alcoholic extract of cube with soap	Effective	McIndoo and Sievers (239) in 1924
Ditto	Cube resin in alcohol with soap	Ineffective	Ditto
Aphis sp. A. Nymphs and adults.	Cube dust	Effective	Ditto
Ditto	Cube decoction	Effective but slow	Ditto
Ditto	Hot-water extract of cube	Effective	Ditto
Ditto	Cold alcoholic extract of cube with soap	Effective	Ditto

Classified List of Insects Against Which Cube has been Tested

Insect and Stage of Development	Preparation	Effectiveness	Reference
Homoptera			
Aphididae (continued)			
Aphis sp. B. Nymphs and adults.	Cube dust	Effective	McIndoo and Sievers (239) in 1924
Ditto	Cube decoction	Effective but slow	Ditto
Ditto	Hot-water extract of cube	Effective	Ditto
Ditto	Cold alcoholic extract of cube with soap	Effective	Ditto
Aphis sp. C. Nymphs and adults.	Cold alcoholic extract of cube with kerosene emulsion	Effective	Ditto
Aphis sp. D. Nymphs and adults.	Cold alcoholic extract of cube with kerosene emulsion	Effective	Ditto
Aphis sp. E. Nymphs and adults.	Cold-water extract of cube with soap	Ineffective	Ditto
Ditto	Hot-water extract of cube with soap	Ineffective	Ditto
Ditto	Cold alcoholic extract of cube with soap	Effective	Ditto
Ditto	Cold alcoholic extract of cube with kerosene emulsion	Effective	Ditto
Ditto	Cube resin in alcohol with soap	Ineffective	Ditto
Ditto	Filtrate from cold, concentrated extract of cube precipitated with water	Ineffective	Ditto
Aphis. Nymphs and adults.	Black haiari extract	Excellent	Tattersfield (358) in 1925
Ditto	White haiari extract	Excellent	Ditto
Ditto	Powdered cube root	Repellent	Hamilton (168) in 1933
Ditto	Cube powder + kaolin, talc, whiting, or diatomaceous earth		Barfoot (49) in 1935
Aphis on cabbage. Nymphs and adults.	Cube dust mixtures	Ineffective	Huckett and Hervey (184 and 185) in 1934
Aphis on citrus. Nymphs and adults.	2% extract of leaves of Lonchocarpus sp. A + 1% saponin	45% kill	Worseley (407) in 1934
Ditto	1% extract of leaves of Lonchocarpus sp. A + 1% saponin	25% kill	Ditto

Classified List of Insects Against Which Cube has been Tested

Insect and Stage of Development	Preparation	Effectiveness	Reference
Homoptera			
Aphididae (continued)			
Aphis on citrus. Nymphs and adults.	2% extract of roots of Lonchocarpus sp. A + 1% saponin	50% kill	Worsley (407) in 1934
Ditto	1% extract of roots of Lonchocarpus sp. A + 1% saponin	37.5% kill	Ditto
Ditto	2% extract of leaves of Lonchocarpus sp. B + 1% saponin	37.5% kill	Ditto
Ditto	1% extract of leaves of Lonchocarpus sp. B + 1% saponin	20% kill	Ditto
Ditto	2% extract of roots of Lonchocarpus sp. B + 1% saponin	42.5% kill	Ditto
Ditto	1% extract of roots of Lonchocarpus sp. B + 1% saponin	35% kill	Ditto
Eriosoma lanigerum Hausm. (woolly apple aphid)	Rotenone from cube, in oil	Excellent	Turner (372) in 1932
Macrosiphum liriodendri Mon. . Adults and nymphs.	Cold alcoholic extract of cube with soap	Effective	McIndoo and Sievers (239) in 1934
Macrosiphum rosae L. (rose aphid). Adults and nymphs.	Cold alcoholic extract of cube with soap	Effective	Ditto
Ditto	Benzene extract of cube with soap	Effective	Ditto
Macrosiphum rudbeckiae Fitch (goldenglow aphid). Adults and nymphs.	Cube extract in mineral oil emulsified with powdered skimmed milk, at 1:300,000	68.1 to 74.1% kill	Turner (372) in 1932
Ditto	Cube extract, in mineral oil emulsified with sodium oleate, at 1:250,000	Effective fresh	Ditto
Macrosiphum solanifolii Ashm. (potato aphid). Adults and Nymphs.	Cube dust	Effective	McIndoo and Sievers (239) in 1924
Ditto	Cube infusion	Effective	Ditto
Ditto	Cold-water extract of cube with soap	Ineffective	Ditto

Classified List of Insects Against Which Cube has been Tested

Insect and Stage of Development	Preparation	Effectiveness	Reference
Homoptera			
Aphididae (continued)			
Macrosiphum solanifolii Ashm. (potato aphid). Adults and nymphs.	Cold alcoholic extract of cube with soap	Effective	McIndoo and Sievers (239) in 1924
Ditto	Cold alcoholic extract of cube with kerosene emulsion	Effective	Ditto
Ditto	Filtrate from cold, concentrated alcoholic extract of cube, pptd. with water	Ineffective	Ditto
Ditto	Cube resin in alcohol with soap	Ineffective	Ditto
Macrosiphum solidaginis Fab. Nymphs and adults.	Cube extract in oil, emulsified with a sulphonate emulsifier, at 1:40,000	81.7% kill	Turner (372) in 1932
Macrosiphum sp. A. Nymphs and adults.	Cube dust	Ineffective	McIndoo and Sievers (239) in 1924
Ditto	Hot-water extract of cube with soap	Effective	Ditto
Ditto	Cold alcoholic extract of cube	Effective	Ditto
Ditto	Cold alcoholic extract of cube with soap	Effective	Ditto
Ditto	Benzene extract of cube with soap	Effective	Ditto
Macrosiphum sp. C. Nymphs and adults.	Cube fumigant	Effective	Ditto
Ditto	Cold-water extract of cube with soap	Ineffective	Ditto
Ditto	Cold alcoholic extract of cube with soap	Effective	Ditto
Ditto	Cold alcoholic extract of cube with kerosene emulsion	Effective	Ditto
Ditto	Filtrate from cold, concentrated alcoholic extract of cube pptd. with water	Ineffective	Ditto

Classified List of Insects Against Which Cube has been Tested

Insect and Stage of Development	Preparation	Effectiveness	Reference
Homoptera			
Aphididae (continued)			
Macrosiphum sp. C. Nymphs and adults.	Cube resin in alcohol with soap	Ineffective	McIndoo and Sievers (239) in 1924
Myzus persicae Sulz. (green peach aphid). Nymphs and adults.	Cube extract, in sulphonated mineral oil, diluted to 1:200,000	37.5% kill	Turner (372) in 1932
Rhopalosiphum (Aphis) pseudobrassicae (Davis) (turnip aphid). Nymphs and adults.	Rotenone from cube, 1:40,000	Excellent	Ditto
Ditto	Rotenone from cube, 1:50,000	Not so satisfactory	Ditto
Aleyrodidae			
Dialeurodes citri Ashm. (citrus whitefly). Eggs.	Cube extract 1:50,000, oil 0.5%, powdered milk emulsifier	23.6% kill (10.5% by check oil)	Ditto
Dialeurodes citri Ashm. . Larvae.	Rotenone from cube 1:75,000, oil 0.33%, powdered milk emulsifier	97.4% kill (79.9% by check oil)	Ditto
Coccidae			
Aspidiotus perniciosus Comst. (San Jose scale). Over-wintering females.	Cube extract 1:12,500, oil 1.0%, powdered milk emulsifier	99.6% kill (96.4% by check oil)	Ditto
Aulascaspis rosae Bouche (rose scale)	Rotenone from cube, in oil	Excellent	Ditto
Chionaspis pinifoliae Fitch (pine needle scale). Half-grown females.	Rotenone from cube 1:25,000, oil 1.0%, powdered milk emulsifier	100.0% kill (5.0% by check oil)	Ditto
Chrysomphalus aonidum L. (over-wintering scale)	Rotenone from cube, in oil	Excellent	Ditto
Chrysomphalus aurantii Mask. (Calif. red scale)	Extracts of white and black haiari in kerosene-water	Ineffective	Smith (339) in 1929 and (271) in 1932
Ditto	Extracts of white and black haiari in spray oils	Ineffective	Ditto
Pseudococcus citri Risso (greenhouse mealybug)	Rotenone from cube, in oil	Excellent	Turner (372) in 1932
Saissetia hemisphaerica Targ. (hemispherical scale)	Rotenone from cube, in oil	Excellent	Ditto

Classified List of Insects Against Which Cube has been Tested

Insect and Stage of Development	Preparation	Effectiveness	Reference
Homoptera			
Membracidae			
Stictocephala festina Say (threecornered alfalfa hopper)	Cube dust	80% control	Cassidy and Barber (78) in 1935
Jassidae			
Typhlocyba pomaria McAtee (apple leafhopper). Nymph.	Cube extract 1:25,000 oil 0.5%, powdered milk emulsifier	82.0% kill	Turner (372) in 1932
Leafhopper	Powdered cube root	Repellent	Hamilton (168) in 1933
Hemiptera			
Pentatomidae			
Chlorochroa sayi Stal (Say's stinkbug)	Cube dust	Useless	Cassidy & Barber (78) in 1935
Euschistus impictiventris Stal (Brown cottonbug)	Cube dust	43% control	Ditto
Pyrrhocoridae			
Dysdercus mimulus Hussey	Cube dust	26% control	Ditto
Miridae			
Lygus apicalis Fieb. Nymph.	Cube dust (4% rotenone)	44.8% mortality (check 13.7%)	Smith, Clark & Scales (338) in 1934
Ditto	Cube (4% rotenone) + kaolin (1:1)	15.5% mortality (check 13.7%)	Ditto
Ditto	Cube (4% rotenone) + kaolin (1:3)	15.6% mortality (check 13.7%)	Ditto
Ditto	Cube (4% rotenone) + kaolin (1:7)	22.1% mortality (check 13.7%)	Ditto
Lygus apicalis Fieb. Adult.	Cube dust (4% rotenone)	41.5% mortality (check 18.8%)	Ditto
Ditto	Cube (4% rotenone) + kaolin (1:1)	14.9% mortality (check 18.8%)	Ditto
Ditto	Cube (4% rotenone) + kaolin (1:3)	17.3% mortality (check 18.8%)	Ditto
Ditto	Cube (4% rotenone) + kaolin (1:7)	17.7% mortality (check 18.8%)	Ditto
Lygus sp.	Cube dust	70% control	Cassidy & Barber (78) in 1935

Classified List of Insects Against Which Cube has been Tested

Insect and Stage of Development	Preparation	Effectiveness	Reference
Hemiptera			
Miridae (Continued)			
Psallus seriatus Reut. (cotton flea hopper). Nymph.	Powdered cube root (4% rotenone)	14% control	Ewing (134) in 1934
Psallus seriatus Reut. (cotton flea hopper). Adult.	Powdered cube root (4% rotenone)	9.7% control	Ditto
Coleoptera			
Coccinellidae			
Epilachna varivestis Muls. (= corrupta Muls.) (Mexican bean beetle). Adult.	Cube spray and dust mixtures	Promising	Huckett & Hervey (184 and 185) in 1934
Ditto	Cube (7.7% rotenone), 1-1/2 lbs. per 50 gals., 118 gals. per acre.	92% better control than check	Howard (181) in 1935
Ditto	Cube-talc powder, 0.77% rotenone, 21 lbs. per acre	Effective	Ditto
Lady-beetle sp. Adult.	Cube fumigant	Effective	McIndoo & Sievers (239) in 1934
Byturidae			
Byturus tomentosus Fab. (Raspberry and loganberry beetle)	Cube (6.26% crude rotenone) 1 lb. per 100 imp. gals. + 5 lbs. soap	As effective as derris	Steer (351) in 1934
Scarabaeidae			
Popillia japonica Newm. (Japanese beetle)	Cube resin, 1 or 2 lbs. per 100 gals.	Ineffective as a stomach poison or repellent	Fleming & Baker (139) in 1934
Chrysomelidae			
Epitrix parvula Fab. (tobacco flea beetle). Adult.	Cube powder + tobacco powder or kaolin (1% rotenone)	Effective	Chamberlin (82) in 1933 and 1934
Ditto	Cube dust, 0.05% rotenone	85.7% kill	Chamberlin (83) in 1934
Ditto	Cube dust (0.75%) rotenone), 7-1/2 lbs. per acre	83.2% kill	Chamberlin (84) in 1934
Ditto	Cube + tobacco dust or kaolin (1% rotenone)	Good	Ditto
Leptinotarsa decemlineata Say (Colorado potato-beetle). Larvae.	Cube dust	Effective	McIndoo & Sievers (239) in 1924
Ditto	Cold alcoholic extract of cube with soap	Effective	Ditto

Classified List of Insects Against Which Cube has been Tested

Insect and Stage of Development	Preparation	Effectiveness	Reference
Coleoptera			
Chrysomelidae (continued)			
Leptinotarsa decemlineata Say (Colorado potato-beetle). Adult.	Cold alcoholic extract of cube with soap	Ineffective	McIndoo & Sievers (239) in 1924
Leptinotarsa decemlineata Say (Colorado potato-beetle). Larvae.	Rotenone from cube in mineral oil, 1:25,000	78% kill in 6 days	Turner (372) in 1932
Curculionidae			
Anthonomus eugenii Cano (pepper weevil).	Cube dust (1% rotenone)	54% kill	R. E. Campbell (76) in 1934
Anthonomus grandis Boh. (boll weevil)	Cube (4.0% rotenone) + kaolin (1:1)	41.7% mortality (check 32.8%)	Smith, Clark & Scales (338) in 1934
Ditto	Cube (4% rotenone) + kaolin (1:3)	33.4% mortality (check 32.8%)	Ditto
Ditto	Cube (4% rotenone) + kaolin (1:7)	34.7% mortality (check 32.8%)	Ditto
Ditto	Cube dust (4% rotenone)	75.0% mortality (check 32.8%)	Ditto
Conotrachelus nenuphar Hbst. (plum curculio)	Rotenone from cube	Ineffective	Turner (372) in 1932
Lepidoptera			
Gelechiidae			
Pectinophora gossypiella Saunders (pink bollworm). First-instar larvae.	Cube dust (6% rotenone) + flour (1:1)	100% kill in 2-1/2 hrs.	Chapman & Cavitt (85) in 1934
Ditto	Cube (6% rotenone) + flour (1:3)	Few larvae alive at end of 2 hrs.	Ditto
Ditto	Cube (6% rotenone) + flour (1:7)	100% kill in 2-1/2 hrs.	Ditto
Plutellidae			
Plutella maculipennis Curt. (diamond-back moth). Larvae	Cube dust (0.5% rotenone), 30 lbs. per acre	60.5% reduction	R. E. Campbell (76) in 1934
Olethreutidae			
Carpocapsa pomonella L. (codling moth)	Rotenone from cube	Of some value	Turner (372) in 1932
Carpocapsa pomonella L. (codling moth). Larvae.	Cube-kaolin (1:3) (1% rotenone)	Unsatisfactory	Van Dine (384) in 1935
Ditto	Cube-kaolin (1% rotenone) spray, 10 lbs. per 100 gals.	Compared well with lead arsenate	Childs (383) in 1935
Ditto	Cube-kaolin (1% rotenone) spray	Unsatisfactory	Gentner (383) in 1935

Classified List of Insects Against Which Cube has been Tested

Insect and Stage of Development	Preparation	Effectiveness	Reference
Lepidoptera			
Olethreutidae (Continued)			
Carpocapsa pomonella L. (codling moth). Larvae.	Cube-kaolin (1% rotenone) spray, 10 lbs. per 100 gals.	Unsatisfactory	Haegele (166 and 383) in 1934
Ditto	Cube-kaolin (1% rotenone) spray, 5 lbs. per 100 gals. + 1/2% white oil	Unsatisfactory	Ditto
Grapholitha molesta Busck (oriental fruit moth). Eggs.	Alcoholic extract of cube at 1:200	4.1% control	Driggers (124) in 1928
Ditto	Alcoholic extract of cube root at 1:500	-0.9% control	Ditto
Ditto	Alcoholic extract of cube root at 1:1000	1.1% control	Ditto
Grapholitha molesta Busck (oriental fruit moth)	Rotenone from cube	Ineffective	Turner (372) in 1932
Grapholitha molesta Busck (oriental fruit moth). Eggs.	Rotenone from cube 1:25,000, oil 1.0%, powdered milk emulsifier	96.4% kill (92.9% by check oil)	Ditto
Rhyacionia buoliana Schiff. (European pine shoot moth).	Cube extract + pine oil (pine oil 2% and rotenone 1:12,800)	Excellent	Glasgow (154) in 1933
Ditto	1-1/2 lbs. cube extract (rotenone = 15%) + 2 gals. miscible pine oil in 100 gals. water	Excellent	Anonymous (29) in 1933
Pyralididae			
Citripestis sagittiferella Moore	Haiari	Not stated	Pagden (258) in 1931
Geometridae			
Cheimatobia brumata L. (winter moth). Larvae.	Extract of black haiari stems with 0.25% soap	Very repellent	Gimingham & Tattersfield (148) in 1928
Ditto	Extract of black haiari roots with 0.25% soap	Very repellent	Ditto
Ditto	Extract of white haiari stems with 0.25% soap	Very repellent	Ditto
Ditto	Extract of white Haiari roots with 0.25% soap	Very repellent	Ditto
Selenia tetralunaria Hufn. Larvae.	Extract of black haiari stems with 0.25% soap	Very repellent	Ditto
Ditto	Extract of black haiari roots with 0.25% soap	Very repellent	Ditto
Ditto	Extract of white haiari stems with 0.25% soap	Very repellent	Ditto

Classified List of Insects Against Which Cube has been Tested

Insect and Stage of Development	Preparation	Effectiveness	Reference
Lepidoptera			
Geometridae (Continued)			
Selenia tetralunaria Hufn. Larvae.	Extract of white haiari roots with 0.25% soap	Very repellent	Gimingham & Tattersfield (148) in 1928
Ditto	Alcoholic extract of black haiari	Effective	Tattersfield & Gimingham (363) in 1932
Canker worms on apple. Larvae.	Cube extract 1:25,000 and 1:12,500	Repellent, did not kill	Turner (372) in 1929
Lymantriidae			
Notolophus antiqua L. (Rusty tussock moth). Larvae.	Extract of black haiari stems with 0.25% soap	Very repellent	Gimingham & Tattersfield (148) in 1928
Ditto	Extract of black haiari roots with 0.25% soap	Very repellent	Ditto
Ditto	Extract of white haiari stems with 0.25% soap	Very repellent	Ditto
Ditto	Extract of white haiari roots with 0.25% soap	Very repellent	Ditto
Ditto	Alcoholic extract of black haiari	Effective	Tattersfield & Gimingham (363) in 1932
Bombycidae			
Bombyx mori L. (silkworm). Larvae	Cold alcoholic extract of cube	Effective	McIndoo & Sievers (239) in 1924
Ditto	Water extract of Lonchocarpus sp.	Ineffective	Ditto
Ditto	Water extract of moetoepoe leaves	Ineffective	Ditto
Ditto	Water extract of moetoepoe wood	Effective	Ditto
Ditto	Water extract of necoetoe leaves	Very slow	Ditto
Ditto	Water extract of tssikoena	Slightly effective	Ditto
Lasiocampidae			
Malacosoma americana Fab. (eastern tent caterpillar). Larvae.	Emulsified mineral oil containing cube extract (1:25,000)	Effective as a deterrent	Turner (372) in 1929
Ditto	Cube extract in oil, sulphonate emulsifier	62.0% kill (12.0% by check oil)	Ditto

Classified List of Insects Against Which Cube has been Tested

Insect and Stage of Development	Preparation	Effectiveness	Reference
Lepidoptera			
Noctuidae			
Alabama argillacea Hbn. (cotton leafworm). Larvae.	Cube (4% rotenone) + kaolin (1:1)	40.0% mortality (check 1.4%)	Smith, Clark & Scales (338) in 1934
Ditto	Cube (4% rotenone) + kaolin (1:3)	14.7% mortality (check 1.4%)	Ditto
Ditto	Cube (4% rotenone) + kaolin (1:7)	9.4 mortality (check 1.4%)	Ditto
Ditto	Cube dust (4% rotenone)	59.7% mortality (check 1.4%)	Ditto
Autographa brassicae Riley (cabbage looper). Larvae.	Cube dust (0.5% rotenone), 30 lbs. per acre	34.4% reduction	R. E. Campbell (76) in 1934
Ceramica picta Harr. (zebra caterpillar). Larvae.	Cube powder	Ineffective	Huckett & Hervey (184 and 185) in 1935
Heliothis obsoleta Fab. (corn ear worm). Larvae.	Cube	Ineffective	Ditto
Graphiphora gothica L. (birch leaf miner)	Extract of black haiari stems with 0.25% soap	Slightly effective	Gimingham & Tattersfield (148) in 1928
Graphiphora gothica L. (birch leaf miner). Young larvae.	Old extract of black haiari stems	Ineffective	Tattersfield & Gimingham (365) in 1932
Xylomyges eridania Haw. (southern army worm). Larvae.	Proprietary cube dust, 0.57% rotenone, 0.3 mg. per sq. in.	Poor	Wisecup (405) in 1933
Pieridae			
Ascia (Pieris) rapae L. (imported cabbage worm). Larvae.	Proprietary cube dust, supposedly 0.6% rotenone	Inferior to derris dust (rotenone = 0.6%)	Stahl (346) in 1933
Ditto	Cube dust (0.33% rotenone)	Unsatisfactory	Huckett & Hervey (184 and 185) in 1934
Ditto	Cube dust (0.5 to 1.0% rotenone)	Satisfactory	Ditto
Ditto	Cube dusts	Effective	Ditto
Ditto	Cube dust (0.5% rotenone), 30 lbs. per acre	47.7% reduction	R. E. Campbell (76) in 1934
Ditto	Cube root as dust or spray	Effective	Howard (181) in 1935
Ditto	Cube powder(0.1% rotenone)	Effective	List & Sweetman (232) in 1935
Ditto	Cube powder + Celite FC (0.5% rotenone)	Effective	Ditto
Ditto	Cube dust	Not as effective as derris	Walker & Anderson (391) in 1935

Classified List of Insects Against Which Cube has been Tested

Insect and Stage of Development	Preparation	Effectiveness	Reference
Unclassified Lepidoptera			
Webworms. Larvae.	Cold alcoholic extract of cube with soap	Ineffective	McIndoo & Sievers (239) in 1924
Hymenoptera			
Tenthredinidae			
Fenusa pumila Klug. Larvae in mines.	Rotenone from cube 1:25,000, oil 1.0%, powdered milk emulsifier	74.0% kill (3.0% by check oil)	Turner (372) in 1932
Pteronidea ribesii Scop. (imported currant worm). Eggs.	Cube extract 1:25,000, oil 0.5%, sulphonate emulsifier	100.0% kill (12.0% by check oil)	Ditto
Pteronidea ribesii Scop. (imported currant worm). Larvae.	Cube extract	100% kill in 3 days (84% of check died)	Ditto
Ditto	Cube extract, 1:25,000	80% kill in 24 hrs. (15% of check died)	Ditto
Sawfly. Larvae.	Cold alcoholic extract of cube with soap	Effective	McIndoo & Sievers (239) in 1924
Formicidae			
Dolichoderus (Hypoclinea) bidens Latr. Adult.	Nekoe water	Useless	Reijne (283) in 1919
Ditto	Phytophiline	Excellent	Ditto
Apidae			
Apis mellifera L. (honeybee). Adult.	Cube root, 1:100, with honey (50:50 by vol.)	100% kill in 24 hrs.	Ginsburg (150) in 1928
Ditto	Cube root, 1:200, with honey (50:50)	100% kill in 48 hrs.	Ditto
Ditto	Alcoholic extract of cube root, 1:250, with honey (50:50)	87% kill in 48 hrs.	Ditto
Ditto	Cube root, 1:400, with honey (50:50)	84% kill in 48 hrs.	Ditto
Ditto	Alcoholic cube root extract, 1:500, with honey (50:50)	36% kill in 48 hrs.	Ditto
Diptera			
Culicidae			
Mosquito. Larvae.	Cube (in lab.)	Effective	Ginsburg (144) in 1928
Ditto	Cube (outdoors)	Ineffective	Ditto

Classified List of Insects Against Which Cube has been Tested

Insect and Stage of Development	Preparation	Effectiveness	Reference
Diptera			
Cecidomyiidae			
Monarthropalpus buxi Lab. (boxwood leaf-miner)	Rotenone from cube	Ineffective	Turner (372) in 1932
Anthomyidae			
Hylemyia brassicae Bouché (cabbage maggot). Larvae	Rotenone from cube 1:5,000	Comparable to $HgCl_2$ at 1:1,280	Ditto
Muscidae			
Musca domestica L. (house fly). Adult.	Extract of 10 g. of cube root in 100 cc. of kerosene	68.2 to 92.5% kill in 3 days	Campbell, Sullivan & Jones (75) in 1934
Ditto	Kerosene extract of haiari stems	Less effective than cube	Ditto
Oestridae			
Hypoderma sp. on cattle (ox warble). Larvae.	100 mesh cube powder	100% kill by one application	Bishopp et al. (59) in 1930
Ditto	Cube powder	Effective	U. S. Dept. Agr. (375) in 19[illegible]
Ditto	Cube wash	Effective	Davies & Jones (113) in 1932
Ditto	1/4 lb. cube root per imp. gal. water	Effective	McDougall (236) in 1934
Ditto	1/2 lb. cube powder per imp. gal. water	Effective	Ditto
Unclassified insects			
Cabbage insects	Cube dusts, 0.5-1% rotenone		Huckett (183) in 1933
Caterpillars. Larvae.	Black haiari	Effective	Tattersfield, Gimingham & Morris (364) in 1926
Ditto	White haiari	Effective	Ditto
Household insects	Derris and cube	Less satisfactory than pyrethrum	John Powell & Co., Inc. (265) in 1934
Insects on coco plants	Rotenone from cube	Effective	Cavanaugh (74) in 1932
Insects on coffee plants	Rotenone from cube	Effective	Ditto
Sheep insects	Water treated with cube	Effective as a dip	Killip & Smith (210) in 1931

Classified List of Insects Against Which Cube has been Tested

Insect and Stage of Development	Preparation	Effectiveness	Reference
Acarina			
Tetranychidae			
Paratetranychus pilosus C. & F. (European red mite). Eggs.	Cube extract, 1:25,000, oil 2.0%, sulphonate emulsifier	86.9% kill (89.6% by check oil)	Turner (372) in 1932
Tetranychus telarius L. (common red spider). Adult.	Cube extract 1:12,500, oil 1.0%, powdered milk emulsifier	70.0% kill (14.0% by check oil)	Ditto
Ixodidae			
Ticks on cattle	Cube wash	Effective	Allen (38) in 1921
Ditto	Wash of latex from roots of Lonchocarpus nicou		Williams (403) in 1934
Sarcoptidae			
Mange mites on sheep	Suspension of ground cube root in sodium carbonate solution	Effective	Preston (278) in 1934
Mange on llamas	1 part cube powder + 100 parts oil	Effective	Ditto
Unclassified Acarina			
Ticks on sheep	Suspension of ground cube root in sodium carbonate solution	Effective	Ditto
Members of other Phyla			
Slugs	Cube powder + kaolin, talc, whiting or diatomaceous earth	Effective	Barfoot (49) in 1935

Patents

The first mention of a species of Lonchocarpus or of an extract from it in a patent is in United States Patent 1,514,377, issued November 4, 1924, to Dow and Hale (122). They state that a mixture of equal parts benzyl alcohol and a halohydrin (e. g., ethylene chlorohydrin or propylene chlorohydrin) serves as an excellent solvent for timboin. (Timboin, isolated by Pfaff (269) from timbo, may have been impure rotenone.) An insecticide may be prepared by extracting derris root with a halohydrin and admixing with benzyl alcohol.

Dennis (115) on April 16, 1923, filed application for United States Patent 1,621,240, which was granted him on March 15, 1927. This patent covers the use as an insecticide and vermifuge of ground cube root with the fibrous element removed. Cube is stated to be a woody shrub found in Peru and other South American countries which is classified by some native botanists as of the family Solanaceae. Directions are given for preparing a solid extract of cube by grinding the roots or plants, extracting with a suitable solvent such as benzol, or alcohol, filtering, and evaporating. The solid extract has a light straw color and is odorless and tasteless.

> "For identification, the powder may be subjected to the action of concentrated sulphuric acid and dilute nitric acid, whereupon it gives a bright clear red color. By the addition of potassium hydroxide in nearly equal volume, a vigorous action is obtained, and the solution turns to a yellowish pink. A further addition of potassium hydroxide produces a stable brown solution.
>
> "The compound in the form of powder or dust may be used as an insecticide with talcum powder, cornstarch or other carrier. It is very effective against flies, roaches and other insects. It is my belief that the powder sets up an irritation of the breathing apparatus which results in early death.
>
> "The compound can be used with water or with soap and water or other emulsifying agent, as a wash or spray for plants, animals or trees. It is effective against aphids, beetles, some insects and worms.
>
> "It can be used as an extract with alcohol for similar purposes, for instance as a wash for ticks on cattle.
>
> "As an alcoholic extract, tests show the solution to have slightly greater effectiveness when sprayed on the cotton aphid than nicotine sulphate. Experience shows that it is eight times as effective as similar derris extract.

"The proportions of the compound and the carrier may be varied as desired for different purposes.

"For certain purposes, it is desirable to use the alcoholic extract in a soap and water emulsification. A suitable solution for aphids can be made by using the extract from one-third pound of powder in one hundred gallons of soap solution."

In a reissue of this patent (reissue 18,667 of November 22, 1932) Dennis (117) corrected the information concerning the botanical origin of cube given in his original patent 1,621,240, stating: "While the exact botanical classification of the plant is not altogether certain it is believed to be a species of the genus Lonchocarpus of the family Leguminosae."

Dennis (116) in Canadian Patent 293,233, issued September 24, 1929, makes essentially the same claims for ground cube root with the fibrous element removed and for an extract of cube root as he previously made it in his United States Patents.

The Standard Oil Development Company (349) was granted, on June 15, 1931, British Patent 350,897, which covers an insecticidal composition comprising petroleum white oil, derris or cube extract, and an emulsifying agent. An extract of any plant having insecticidal properties may be used.

"This vegetable principle may be the active principle of a plant of the class known as fish poisons, mostly belonging to the order of Leguminosae and genera Derris, Lonchocarpus and Tephrosia, etc., and known variously as tuba, cube (cubi), haiari, timbo, etc."

The preparation of a suitable extract from cube root is described. Dry cube root yielded 5.25 percent total extract with dry isopropyl alcohol. Eighty grams of this extract were fed into a colloid mill with a solution of 750 grams of oil-soluble sodium sulphonate derived from petroleum oil, in 2.5 liters of technically pure white oil. Water was also added in the amount of 1.5 liters. A thick emulsion resulted similar in appearance to mayonnaise and ready for marketing. Part of this preparation was diluted with 50 times its weight of water and gave an effective insecticidal spray for horticultural purposes.

McGill (237), in United States Patent 1,854,948, issued April 19, 1932, and assigned to the Standard Oil Company of Indiana, claims "A solution adapted for use in rendering fabrics mothproof comprising the active principle of haiari in petroleum naphtha having a boiling point between 450 and 550° F." An extract of haiari may be prepared by allowing a mixture of 1 pound ground material with 1 gallon of petroleum naphtha (boiling between approximately 300 and 400° F.) to stand at room temperature for 5 to 7 days with occasional agitation. If the mixture is heated to 150 to 200° F. the time of extraction is reduced. In using black haiari it is preferred to extract both the roots and stems, while in the case of white haiari it is preferred to extract the stems and leaves.

In United States patent 1,928,256, issued September 26, 1933, to Jones (195), claim is made for "A process of producing a liquid insecticide containing rotenone in a colloidal state of dispersion which consists substantially in dissolving a plant extract containing rotenone in pyridine and adding this solution to water with subsequent mixing." In this patent it is stated that "In place of pure rotenone, a crude rotenone, or an extract of a plant containing rotenone may be used. For example extractives from Derris elliptica, Lonchocarpus and other plants known to contain rotenone may be employed."

In United States patent 1,928,968, issued October 3, 1933, to Jones (196) claim is made for "A process of producing a liquid insecticide containing rotenone in a colloidal state of dispersion which consists in dissolving a plant extract containing rotenone in acetone, and adding this solution to water in the presence of tannic acid with subsequent mixing." In this patent it is also stated that "In place of pure rotenone, a crude rotenone, or an extract of a plant containing rotenone may be used. For example extractives from Derris elliptica, Lonchocarpus and other plants known to contain rotenone may be employed." Solvents mentioned in this patent are acetic acid, acetone, diacetone alcohol, ethyl alcohol, ethyl formate, ethylene chlorohydrin, and pyridine.

In United States patent 1,934,057, issued November 7, 1933, to Grant (156) and assigned to the Standard Oil Development Company, claim is made for "An insecticide or insect repellent, comprising a petroleum white oil, an extract of a plant belonging to the class known as fish poisons, and an emulsifying agent." Cube is specifically mentioned in this patent as one of the plants that can be used. Directions are given for the preparation of a finished insecticide using a solid extract of cube obtained with isopropyl alcohol. These directions are identical with those given in British Patent 350,897.

In United States patent 1,940,899, issued December 26, 1933, to Badertscher (46) and assigned to McCormick & Co., Inc., Baltimore, Md., it is stated that rotenone may be obtained by extraction of the roots of certain species of South American Lonchocarpus, such as cube, haiari and timbo, with acetone or carbon tetrachloride. In this patent it is also stated that talc impregnated with pyrethrum extract may be admixed, if desired, with ground cube root in the proportion of 60 parts coated talc to 40 parts of ground cube or derris root or a mixture thereof.

In United States patent 1,940,646, issued December 19, 1933, to Grant (157) and assigned to the Standard Oil Development Company, a claim is made as follows: "In the manufacture of insecticides, the improvement which comprises extracting the active insecticidal principles from vegetable matter of the group consisting of pyrethrum, derris, cube, and tephrosia, with a mixture of an organic solvent, a blending agent and an emulsifying agent." As the organic solvent it is preferred to use naphtha, kerosene, or a light lubricating oil. The agent for blending or making homogeneous the petroleum distillate or other organic solvent with water is preferably an oil-soluble sulphonate, such as may be formed by neutralizing oil which has been subjected to the action of fuming sulphuric acid. The oil-soluble sulphonates are extracted from the oil by a solvent and are suitably separated from it. In general, one or more other emulsifying or blending agents are combined with the sulphonate, for example, Turkey red oil, rosin soap, sulphonated vegetable or mineral oils, steam distilled pine oil, terpineol, cresol, cyclohexanol, dichlorobenzene, chloronaphthalene, one or more of the higher alcohols, such as isopropyl or secondary butyl or secondary amyl alcohol, ketones, or cyclohexanol or its homologues. Some of the above materials may serve both as blending agents and as emulsifying agents. Such materials having this dual property are oil-soluble sulphonates, Turkey red oil, sulphonated vegetable or animal oils, and to a certain extent also rosin soap. However, it should be explained that even though this solvent to be used for the extraction contains an emulsifying agent yet it is clear and homogeneous while being used for the extraction and does not become emulsified until the extraction has been completed and the solution is mixed with water in preparation for use. A suitable composite solvent consists of mineral seal oil, 171.3 cc.; oil-soluble sulphonate, 30.2 cc.; potash rosin soap, 10.0 gms.; hexahydrophenol, 10.0 cc.; ethyl methyl ketone, 10.0 cc.; cresol, U.S.P., 10.0 cc.; water, 24.0 cc.

In United States patent 1,942,104, issued January 2, 1934, to Jones (198), claim is made for "A process for making a chemical compound of rotenone and carbon tetrachloride which consists substantially in extracting the roots of plants of the geneous <u>Lonchocarpus</u> with warm carbon tetrachloride, and crystallizing." The following specific directions are given for carrying out this process: "Five kilograms of the roots of <u>Lonchocarpus</u>

nicou (cube root) is percolated with 30 to 40 liters of carbon tetrachloride at a temperature of 50° C. The extract so obtained is evaporated to a volume of 1 liter. This evaporated extract is cooled until crystallization occurs. The separated material is filtered, excess solvent removed by suction and the crystalline mass dried in air."

Adams (35), in Canadian patent 338,896, issued January 23, 1934, and assigned to the Standard Oil Company (of Indiana), claims a mothproofing composition comprising a chlorinated hydrocarbon extract of cube. He also claims such a cube extract incorporated in a mixture of 9 parts light hydrocarbon oil and 1 part chlorinated hydrocarbon or dissolved in a petroleum naphtha having a boiling range of about 450 to 550° F.

McGill (238) has had issued to him Canadian patent 338,897, dated January 23, 1934, which is essentially the same as United States patent 1,854,948. Claim is made for a mothproofing solution comprising a volatile solvent (preferably petroleum naphtha boiling between 450 and 550° F.) and the active principle of haiari.

Haller and Schaffer (167) in United States patent 1,945,312 issued January 30, 1934, claim the process of making dihydrorotenone which comprises hydrogenating an extract of Lonchocarpus nicou (cube root) dissolved in an organic solvent in the presence of a nikel catalyst obtained by alloying equal parts of nickel and aluminum and then dissolving out the latter with aqueous sodium hydroxide. The details of this process are as follows:

> "One hundred grams of Lonchocarpus nicou (cube root) are exhaustively percolated with ether in the usual manner. The ether extract is concentrated to a thick syrup and then dissolved in 100 cc. of butyl acetate. The solution is placed in the reaction bottle of a suitable catalytic reduction apparatus and 1.5 gms. of nickel catalyst suspended in 10 cc. butyl acetate are added. The air is replaced with hydrogen and the mixture is shaken with hydrogen until hydrogen is no longer absorbed. The solution is filtered from the catalyst and concentrated to a small volume. Ten to 25 cc. of ethyl alcohol are then added. The solution soon deposits dihydrorotenone. It is filtered off and washed with a little alcohol. The product is practically pure dihydrorotenone."

The significance of the Haller-Schaffer process of making dihydrorotenone and hydrogenated extracts of rotenone-bearing plants is apparent when it is remembered that dihydrorotenone is more toxic than rotenone to fish (Gersdorff, Jour. Amer. Chem. Soc. 52: 5051-5056. 1930) and to mosquito larvae (Jones, Campbell, and Sullivan, 201). It is more stable than rotenone to direct sunlight (Jones et al. Jour. Econ. Ent. 26: 451-470., 1933) and its use in admixture with the pyrethrins avoids the Fulton patent (U. S. Patent 1,967,024 issued July 17, 1934) covering mixtures of rotenone with the pyrethrins.

Dupre & Co. (128) in French patent 767,445, issued August 25, 1934, have patented a process of obtaining insecticides the efficacy of which results from the combined action of three ingredients, (1) extract of the wood of Quassia amara, (2) vegetable oil and (3) rotenone (or extract of derris or of cube) which are stabilized by sassafras oil and emulsified by oleic acid and triethanolamine. For example, an insecticide is made from 10 kg. quassia extract, 4 kg. triethanolamine, 50 kg. vegetable oil, 11 kg. oleic acid, 1 kg. rotenone, and 100 gm. sassafras oil. The final emulsion is diluted to 1:100 or 1:150 for use.

Sankowsky and Fulton (324), in Canadian Patent 340,315, issued March 20, 1934, claim an improved insecticide obtained by the extraction of petroleum naphtha with liquid sulphur dioxide and boiling within the range of 350 to 600° F., and containing the extractives of at least one of the plants selected from the group consisting of pyrethrum, cube, derris, and the like. The product obtained by extracting petroleum naphtha with liquid sulphur dioxide is rich in unsaturated hydrocarbons.

Pfaff and Dunkel (270) in Canadian patent 34_,_83, issued October 16, 1934, claim an insecticidal composition, comprising a solution of an insecticidal plant extract and/or a compound of the group comprising esters and ethers of benzoic acid and substitution products thereof in a hydrogenated mineral oil boiling between about 100° C. and 300° C. and having a specific gravity of about 0.75 to 0.85 at 20° C. Cube extract could be included under the designation "insecticidal plant extract."

Schotte and Görnitz (328), in Canadian patent 348,379, issued February 26, 1935, claim an insecticidal preparation consisting of a mixture containing extracts of drugs containing rotenon and veratrin. This claim embraces cube extract.

Buc (68), in United States patent 2,013,028, issued September 3, 1935, and assigned to the Standard Oil Development Company, claims an insecticidal composition consisting of a non-volatile viscous petroleum oil containing not less than

0.1 percent of insecticidal material selected from the group consisting of rotenone and rotenoids and not less than 1.5 percent of a non-volatile highly halogenated hydrocarbon. Buc defines rotenone as the active principle of certain plants known as fish poisons, such as derris, cube, etc. The term rotenoid is used to designate insecticidal principles of the same plants which are not exactly identical with rotenone in their chemical constitution but have a similar insecticidal action. A suitable household insecticide may be made by dissolving 1 gram rotenone and 20 grams halogenated naphthalene of specific gravity 1.25 in 1 liter of kerosene. A horticultural spray may be made by dissolving 2 grams rotenone and 30 grams halogenated naphthalene (halowax oil) of specific gravity 1.25 in 1 liter light lubricating oil.

Roark (290, 302, 304) has reviewed patents relating to cube as well as those relating to derris and _Tephrosia_.

An anonymous writer (34) in 1934 stated that Dennis "is the holder of U. S. patent Reissue 18,667, covering the use of cube root (_Lonchocarpus nicou_) _in any form_ as an insecticide and vermifuge."

Proprietary Insecticides Made from Cube

According to a bulletin of the Koloniaal Museum of Haarlem, Holland, (224) issued in 1911, Nekoe root (_Lonchocarpus_ species) is used in preparing the proprietary insecticide Phytophiline, but the manufacturers (272) of this product, in a letter dated April 8, 1933, denied this.

At present (1935) many insecticide manufacturers are using cube in place of derris, or mixtures of the two, in the preparation of various proprietary products, but no information concerning the composition of these rotenone preparations is available.

Statistics and Prices

Cube has become commercially available in the United States only within the last few years. Even in South America it formerly was known only in certain localities. For example, E. Higginson (178), Consul General of Peru in New York City, wrote as follows in a letter dated May 29, 1929: "Various inquiries have already been received concerning this root (cube) but our investigation has failed to show whether this root is grown or not in this country." E. Schoenrich (326), American Consul at Arica, Chile, in a letter dated July 10, 1929, stated that cube was not used and was not known in Tacna and Arica, Chile.

Cube became commercially available in the United States in 1932, and Roark (298) called attention to this in December of that year. According to Birdsall (48), not more than 5 pounds of cube root to every 95 pounds of derris root were sold in the United States during 1932.

Spoon (344) reports the exportation of nekoe (= stinkwood, stated to be the stemwood of Lonchocarpus chrysophyllus) from Surinam as follows:

Year	Pounds
1920	13,631
1922	977
1926	14,892
1929	8,811
1930	361

Later Spoon (346) and Spoon and Rowaan (347) stated that 6-1/2 tons (13,000 pounds) of nekoe roots were exported from Surinam in 1932.

Bohan (60), commercial attache of the United States Department of Commerce at Lima, Peru, wrote as follows on November 18, 1932:

> "Mr. Julius Losen, of Culda and Hillman, informed us yesterday that his firm is in a position to ship fairly substantial amounts of cube root and that they have approximately five tons of this product available at the moment."

McKee (240), American Vice Consul at Callao-Lima, Peru, on May 8, 1934, reported as follows concerning the Peruvian exportation of barbasco or cube root:

Exported from	Period	Pounds
Iquitos	Jan.-May 1934	266,275 crude
Cabo Blanco Lobitos Lomas Mala	Jan.-Mar. 1934	84,290 crude
Callao	Jan.-Mar. 1934	4,484 ground
All ports	1932	32,277
Iquitos	1933	33,182
All other ports	1933	2,198

The countries of destination in 1934 were shown as the United States, Great Britain, Sweden, France and Germany. More shipments were sent to the United States than to all the other countries combined.

The Bureau of Foreign and Domestic Commerce of the United States Department of Commerce, in a report issued in November 1934 (390), reported the importation into the United States of crude roots, described in entries as cube, barbasco, and timbo, as follows:

Country of origin	Pounds	Value	Period
Peru	243,855	$19,408	Jan.-July, 1934
Brazil	27,322	2,091	"
Surinam	2,134	77	"
Total	273,311	$21,576	

Roark (306), from a study of all available data, has estimated the imports of cube and derris into the United States during the calendar year 1934 to be 500,000 pounds and 1,000,000 pounds, respectively.

Tattersfield (360), in 1935 stated that the exports of derris from Malaya increased from 90 tons in 1930 to 642 tons in 1933, while the production of cube in Peru rose from nil in 1925 to an estimated 300 tons in 1934.

Seltzer (333), American Consul at Para, Brazil, reported on January 31, 1935, as follows: "At the present time there is only one firm in Para that manufactures the timbo root powder. Several trial shipments were made from Manaos during the past two years, but as far as is known, there are no firms there that have yet gone into the business of exporting the timbo roots. Shipments of the roots are being made regularly from Iquitos, Peru. It is understood that in the region around that city the timbo plant is now being cultivated on a large scale."

Young (408) American Consul General, Callao-Lima, Peru, under date of July 19, 1935, reported that the sharp fall in barbasco root prices in Iquitos during July was attributed to manipulation. The price fell from 80 centavos to 30 centavos per kilogram. The Iquitos press has urged that the Peruvian Government intervene in the rotenone market to avoid speculation and to assure the native growers a steadier and higher price. Young also reported that total exports of rotenone (barbasco or cube) from Peru in 1934 amounted to Soles 106,363 in value, while in 1933 they totaled only a value of Soles 7,355 and in 1932 only Soles 2,619, according to the official statistics of the Peruvian customs.

According to a letter from Kahn & Co, (205) dated October 31, 1929, cube roots would yield a much better result if exported unbroken, that is in their full length without unnecessarily cutting or breaking them.

Cube was first advertised in the United States in 1934 by Dennis (118) and by S. B. Penick & Co. (264), and the custom milling of "derris and other rotenone-bearing roots" was also first advertised then by Cyrus Ward & Co. (395).

The selling price of powdered cube is usually a few cents per pound less than that of powdered derris of equal rotenone content. The following prices were quoted by one of the large dealers in derris and cube for deliveries up to September 30, 1935, to all territory east of the Rocky Mountains:

Powdered Derris Root	Rotenone content		
	3 percent	4 percent	5 percent
5 tons up	32¢	37¢	43¢
1 to 5 tons	33¢	38¢	44¢
1000 to 2000 lbs.	35¢	40¢	46¢
Under 1000 lbs.	37¢	42¢	48¢
Powdered Cube Root			
5 tons up	27¢	31¢	36¢
1 to 5 tons	28¢	32¢	37¢
1000 to 2000 lbs.	30¢	34¢	39¢
Under 1000 lbs.	32¢	36¢	41¢

Laws Relating to Cube

Crude cube roots may be imported into the United States duty free, but ground roots must pay an ad valorem duty of 10 percent and extracts must pay an ad valorem duty of 25 percent before entry is permitted.

Hayward (172), of the Bureau of Customs, U. S. Treasury Department, in response to a request concerning the duty applicable to a so-called rotenone powder with a purity of 90 percent, wrote (March 2, 1935) as follows:

> "A derris resin or extract was held by the Court of Customs and Patent Appeals in T. D. 47038 to be a medicinal preparation dutiable at 25 percent ad valorem under paragraph 5 of the Tariff Act of 1930. In a decision, an abstract of which was published as T. D. 47230 (1), the Bureau held that ground timbo root and ground derris root, vegetable substances which are natural and uncompounded, advanced in value by grinding, and not containing alcohol, and which are used as insecticides in manner and purpose identical with the manner and purpose in which ground pyrethrum flowers are used, are dutiable at 10 percent ad valorem under paragraphs 35 and 1559; and that other extracts used as insecticides and not chiefly used for the prevention of disease in man or animals are dutiable at 20 percent ad valorem under paragraph 1558 as nonenumerated manufactures."

The Food and Drug Administration of the United States Department of Agriculture permits all material in cube that is extractable with ether to be labeled "Active ingredients." Present commercial cube root ranges from 10 to 20 percent (average about 15 percent) total ether extract.

Certain South American countries have restricted the exportation of cube products. The State of Para (135) of Brazil, in Decree No. 1259 of April 3, 1934, permits the planting of only two kinds of timbo, namely "macaquinho" and "urucu". Timbo may be exported only when ground and packed in barrels or tin cans hermetically sealed, and only when an analysis shows not less than 3.5 percent active principle (rotenone) to be present.

Peru has forbidden the exportation, without the permission of the government, of living cube plants or barbasco seed that may be used for propagation. (McKee, 240.)

On April 4, 1933, the President of the Republic of Peru (322) issued Supreme Decree No. 20 as follows (translation):

1. The cultivation and industrial exploitation of the plants known, without distinction, in the country by the names of "cube" or "barbasco" and belonging to the genera *Lonchocarpus*, *Tephrosia* or *Cracca*, *Apurimacia*, *Jacquinia*, and *Serjania*, are declared to be of public utility.

2. It is absolutely prohibited for slips, seeds or fresh roots of these vegetables to leave the country.

3. There shall be permitted only the exportation of roots containing a maximum of ten percent moisture until the Government shall have erected the mills of extraction mentioned.

4. In order to export the roots mentioned in the previous article the interested parties must apply to the Direccion de Agricultura y Ganaderia of the Ministerio de Fomento for the respective permit and the certificate of chemical analysis.

5. The Direccion de Agricultura y Ganaderia is authorized to study the installation of mills to extract the rotenone at the places of production deemed most suitable.

6. The Direccion de Agricultura y Ganaderia shall adopt the regulations concerning the development and scientific cultivation of these plants and their best industrial exploitation in order that while they are being used to the best advantage there may be assured to the country a national monopoly.

On May 23, 1933, Ministerial Resolution No. 195 was decreed (323). This reads as follows (translation):

1. The dealers in cube or barbasco roots who export the said roots through the river port of Iquitos must send, by air mail, to the Technical Section of Agriculture of the Department of this branch of the Government, through the medium of the agricultural engineers in the service of the state in the Department of Loreto, an average sample weighing 500 grams taken from each shipment in order that it may be analyzed in the laboratories of the National Agricultural and Veterinary school;

2. The exporters shall deposit with the said agricultural engineers the sum of S/. 30.00 to cover the chemical analysis of each sample, which money shall be remitted to the Treasury of the National Agricultural and Veterinary School in order that it may be placed in a special account opened under the name of "Chemical Control of Exportation of Agricultural Products" and the revenues shall be devoted to the needs of that section and those (needs) determined by the "Direccion" of this branch of the Government:

3. The Customs at Iquitos shall permit the exportation of the Cube or Barbasco roots only upon presentation of the radio-graphic authorization which the "Direccion de Agricultura y Ganaderia" shall issue to the agricultural engineers in the Service of the State in the above-mentioned department.

Under date of July 5, 1933, the ministerial resolution of May 23 was modified by Alayza (37) in a supplementary resolution reading as follows (translation):

1. Dealers in cube or barbasco roots who export said product through the river port of Iquitos are hereby exempted from the required analysis until the installation in the said port of a chemical laboratory, only the authorization of the Customs officials in Iquitos being necessary for the said exportations.

2. It is hereby recommended to the exporters that the roots be transmitted in the driest form possible.

Rohwer (308) and Strong (357), of the Bureau of Entomology and Plant Quarantine, United States Department of Agriculture, have called attention to these Peruvian laws.

Faria (135), on April 3, 1934, issued Decree No. 1259 of the State of Para, Brazil. This decree makes the cultivation, commerce and exportation of timbo subject to regulation by the Directorate of Agriculture, Industry and Commerce. Only the species of timbo known as "macaquinho" and "urucu" may be cultivated. Other varieties shall be utilized only when they show a yield of the active element greater than 3.5 percent. The exportation of all varieties of timbo in the root is prohibited and for the purpose of exportation these must be duly prepared, dried, and reduced to powder by grinding, and packed in barrels or in tin cans, hermetically sealed. Timbo shall be exported

only when accompanied by a certificate which shall indicate the amount of moisture and of the active element, rotenone. Only timbo containing at least 3.5 percent of the active element, in the well-dried product may be exported.

Seltzer (333), on January 31, 1935, called attention to this decree.

Reviews and General Articles on Cube

There are many general reviews of fish-poisoning plants which include mention of cube, timbo, haiari, or various species of *Lonchocarpus*.

Accounts of the work of the Insecticide Division with cube and other fish poison plants in the effort to find new insecticides are given by anonymous writers (14, 15, 26, 32 and 378). Mention of the occurrence of rotenone in cube is made by various writers (16, 17, 18, 19, 23, 25, 27, 28, 36, 42, 45, 69, 73, 79, 90, 103, 112, 120, 138, 145, 147, 153, 154, 174, 176, 180, 190, 192, 202, 203, 212, 225, 228, 245, 256, 288, 325, 345, 346, 374, 378, 379, 380).

Reference to cube is made by Knight (213, 214, 216, 217, 218, 219 and 220), by Knight and Skinner (222, 223), and by Pfältzer (271).

Reviews or reports which include reference to cube or haiari are the following: Anonymous, 3, 6, 7, 8, 9, 10, 11, 13, 20, and 43; Alvord and Dietz, 39; M. B., 44; de Bussy, 70; Ginsburg, 151; Headlee, 173; Huckett, 183; Hyde, 187; Jones, 192; McDonnell, 235; Manschke, 247; Marlatt, 248; O'Brien, 255; Pannewitz, 261; Roark, 286, 287, 289, 295, 297, 299, 300 and 303; Rothamsted, 311, 312, M. S., 318; Schuette, 329; U. S. Department of Agriculture, 373, 381; Wehmer, 398; and Williams, 402, 403.

Mention of botanical exploring parties interested in cube is made in 21 and 335.

Facetious reference to the discovery of "rotenone" by the Indians in the upper Amazon Valley is made in Soap (31).

Roark (301) has reviewed what is known concerning the chemistry of *Lonchocarpus latifolius* H. B. K., *L. nicou* (Aubl.) DC., and the species of *Lonchocarpus* known locally as nekoe, white haiari, and black haiari.

Roark in 1931 (296) compiled information concerning various species of *Lonchocarpus* from correspondence from American Consuls in Georgetown, British Guiana; Colombo, Ceylon; Guatemala, Guatemala; and Rio de Janeiro, Brazil. Species mentioned include *Lonchocarpus guatemalensis* Benth., *izabalanus* Blake, *peckolti* Waura, and *sericeus* H. B. K.

In 1933 the Bureau of Foreign and Domestic Commerce of the United States Department of Commerce sent out Questionnaire No. 346 requesting information concerning the occurrence and commercial development of cube and other insecticidal plants (102).

According to the Pathfinder (30), Forest Wilson, after returning from a trip in the South American jungles, suggested the use of the "rotan" plant as a spray for insects. The natives use an extract of this plant to poison fish. Rupe (317) refers to the work of Perkin who showed that the dyestuff in _Lonchocarpus cyanescens_ is indigotin. Perrot (268) in 1931 referred to the work of Tattersfield in testing a species of _Lonchocarpus_ from Guiana as an insecticide.

Reference by an anonymous writer (4) is made to the work of Tattersfield and Gimingham in finding tubatoxin (= rotenone) in haiari. Information concerning cube, taken apparently from Townsend (367), is published in Soap (5).

Furse (141) has reported that in 1932 the Imperial Institute of Great Britain received nearly 50 inquiries relating to insecticidal plants, including cube and haiari. The cultivation of _Lonchocarpus_ in the Federated Malay States was suggested by Roark (291) and the possibility of growing _Derris_ and _Lonchocarpus_ in southern Florida was mentioned by Roark (292) in 1930.

In 1931 Roark (293) called attention to the fact that some of the derris root brought into the United States contained no rotenone and suggested that consumers try cube root in case producers were unwilling to supply derris on the basis of a guaranteed rotenone content. In discussing the possibilities of derris as an insecticide, Roark (294) called attention to the high (7 percent) rotenone content of certain samples of cube root and to the use of haiari as an insecticide.

In 1931 W. W. Skinner, of the United States Department of Agriculture (12), visited the Virgin Islands to investigate the possibility of aiding the rehabilitation of agriculture of those islands by growing pyrethrum, derris, and cube. Recent reviews of our knowledge of cube have been published by Roark (303, 304, 305).

Bredeman (66) reported that during 1931 many inquiries were received by the Hamburg Institut für Angewandte Botanik concerning the application and manner of testing of various insecticidal materials, including cube root.

In the Lima, Peru, newspaper La Prensa for August 11, 1934 (33), an article appeared stating that in North America a campaign had been started to discredit barbasco or cube and to popularize derris. It urged that steps be taken to preserve the prestige of cube, as it is a product of great economic importance to Iquitos.

Gstirner (164) has reviewed information on derris, cube and _Tephrosia_ with special reference to chemical methods for their evaluation.

Lapparent (231) erroneously states that cube root (_Lonchocarpus nicou_) reduced to a powder serves the Indians for the manufacture of curare, which really is derived from certain species of _Strychnos_.

Knight (221) has referred to the work of Campbell et al. (75) on kerosene extracts of derris and cube as house fly sprays.

The U. S. Department of Agriculture, through press releases, radio broadcasts, and other means, has publicized its work on cube and this information has become widely disseminated. The U. S. Department of Agriculture (376), in a press release of February 24, 1931, called attention to the proposed trip of W. W. Skinner to the Virgin Islands for the purpose of studying the possibilities of growing such insecticidal plants as pyrethrum, derris and cube. The press release of the U. S. Department of Agriculture of April 13, 1932, in which it is stated that rotenone can be obtained from cube, is referred to by various anonymous writers (22, 24). The U. S. Department of Agriculture (382), in a press release dated November 10, 1933, reviews the address of H. G. Knight before the Midland Section of the American Chemical Society meeting in Saginaw, Mich., in which reference is made to the occurrence of rotenone in cube. Eisenhower and Gapen (130), in a radio interview broadcast August 20, 1935, in the Department of Agriculture period on the National Farm and Home Hour of the N. B. C., on the subject of seeking new weapons for fighting insects, referred to the occurrence of rotenone in derris and cube.

An anonymous (2) writer in 1890 stated that it is noteworthy that the derris belongs to a group of the Leguminosae which furnished fish poisons in many parts of the world, viz., _Lonchocarpus_, _Millettia_, and _Piscidia_.

Winkler (404) in 1912 described _Lonchocarpus cyanescens_ and _L. sericeus_ from Africa. The former species yields the so-called Yoruba indigo.

Gimlette (149) in 1923 mentioned that Lonchocarpus is used as a fish poison.

Maheu (241) in 1925 referred to the Peruvian plant cube as one of the few plants known to have marked insecticidal properties.

Croucher (107) in 1928 reviewed the work of Tattersfield on the white and black haiari from British Guiana.

Bailey and Bailey (47) in 1929 defined nicouline $(C_3H_4O)_n$ as the bitter principle from Robinia nicou Aublet and defined timboin as the active principle $C_{27}H_{26}O_8$ from timbo.

Jones and Smith (204) in 1930 called attention to the work of Geoffroy, who isolated nicouline (= rotenone) from Lonchocarpus nicou.

Browne (67), in 1932, in an interesting account of the work of various investigators on the structure of rotenone, refers to its discovery in 1895 in Lonchocarpus nicou by Geoffroy.

The Rothamsted Experimental Station (314) in its annual report for 1933 reports that investigations have been made on species of Lonchocarpus.

Pagden (259) in 1934 referred to the use of Lonchocarpus and derris as fish poisons.

Tattersfield (360) in 1935 reviewed recent developments in pyrethrum, derris, and cube.

Poole (276) in 1935 reviewed the recent literature on pyrethrum, derris and cube, giving 40 references.

Cates (80) in 1935 wrote that derris and cube were supplementing pyrethrum.

Torres (366), under date of March 21, 1935, submitted a list of Brazilian plants which are either toxic or used as insecticides or fish poisons. Included in this list are 4 species of Lonchocarpus, namely L. densiflorus Benth., L. floribundus Benth., L. nicou DC., and L. urucu Killip and Smith.

Benkert & Co. (53) reviewed recent developments in our knowledge of cube based largely on the reports of Roark (304), Campbell et al. (75), and unpublished data of the Bureau of Entomology and Plant Quarantine. Cube roots ranging from 4 percent to 6 percent rotenone average about three times this amount of ether extractives, that is, cube containing 5 percent rotenone should contain 15 percent total ether extractives. It is suggested that powdered cube root be purchased on the basis of a guaranteed minimum of 5 percent rotenone and 15 percent total ether extractives. Experience has shown that, regardless of analysis, an insecticidal dust made from derris or cube must contain a certain proportion of active root in order to give control. The minimum appears to be 10 pounds to the hundred, and Benkert & Co. recommend 10 to 15 pounds to give a good margin of safety. For this reason it is preferable not to use an exceptionally high test cube in making a dust. On account of inadequate supplies of derris and the lower cost of cube it is predicted that a large portion of the rotenone-containing insecticidal dusts sold commercially during the 1935 season will be based on cube rather than derris.

Summary

Lonchocarpus is a genus of tropical plants belonging to the family Fabaceae (pea family), called Leguminosae or Papilionaceae by some botanists. One species of *Lonchocarpus* is found in Australia, and a few occur in Africa, but the greater number of the 60 described kinds occur in South America and Central America.

Four identified species of *Lonchocarpus*, namely *L. guatemalensis*, *L. latifolius*, *L. nicou*, and *L. velutinus*, and several unidentified species, known locally as black haiari, white haiari, nekoe, timbo, etc., have insecticidal value.

Of these *L. nicou* appears to be the richest in insecticidal constituents. This plant is a climbing shrub which is indigenous to eastern Peru, the Amazon basin of Brazil, Venezuela, and the Guianas. In Peru it is called cube, cubi, conapi, and pacai; in Brazil, timbo; in British Guiana, haiari; in French Guiana, nicou; and in Dutch Guiana, nekoe, stinkwood, and various native names; and in the Spanish-speaking countries where it grows, barbasco. These common names are also applied to many other kinds of plants belonging to several families that share the common property of toxicity to fish.

Lonchocarpus nicou is now being cultivated on a large scale in plantations in South America, and its exportation to the United States and to Europe is rapidly growing. During the period January to July, 1934, 273,311 pounds of crude root, described in entries as cube, barbasco, and timbo, were imported into the United States.

Rotenone and deguelin (constituents of _Derris_ roots and of other fabaceous fish-poison plants) account for the greater part of the insecticidal action of _L. nicou_, but other toxic constituents of unknown composition are also present. The rotenone content of 14 samples of commercial powdered cube root examined during 1934 ranged from 0.5 to 7.7 percent, and the total matter extractable with carbon tetrachloride (which removes all toxic constituents, including rotenone), ranged from 11.6 to 21.6 percent.

In view of the promise of an inexhaustible supply of cheap cube, all persons interested in insect control are urged to investigate carefully the possibilities of this South American plant, that is so rich in rotenone, deguelin, and other potent insecticides.

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